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# SUGAR BEET SEED

## *History and Development*

BY

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# PREFACE

PERHAPS the greatest achievement in plant breeding has been reached by those scientists who have directed their study and applied their knowledge to the amelioration of the sugar beet.

The main object sought in breeding sugar-beet seed has differed from the objects sought in the development of other seeds, in that neither the appearance nor the flavor of the resultant plant or fruit has been the objective; even the increase in size has been of minor importance. The main quest of the scientists who have given their life studies to the amelioration of the beet, has been to change the ratio of its chemical constituents by eliminating a portion of its other substances and replacing them with sugar.

At the time the beet-sugar industry was established in France by Napoleon Bonaparte, sugar was selling at 30 cents per pound, but with the entrance of the temperate zone as a competitor with the tropics in the production of sugar, the price of that product began

to decline and a lower cost of production became imperative, if the industry were to survive.

Prior to the war in Europe the price of sugar was less than one-sixth of what it was when the beet-sugar industry was first established and, although great improvements have been made both in field work and in factory processes, the ability of the industry to produce sugar at present prices is due to the painstaking efforts of scientific seed breeders who have quadrupled the original sugar content of the beets. However valuable have been the results of study in other lines of development, it must be conceded that the quality of sugar-beet seed is the keystone of the arch upon which rests an industry that annually provides the world with one-half of its total supply of sugar.

So important seemed the objective sought by the seed breeders, that for many years the experiments were conducted with the utmost secrecy, and even yet, the growers' methods are treated as trade secrets. The result is a dearth of literature relating to this subject.

The observations made in the following pages are based upon information obtained in 1908, 1910, and 1911, while visiting sugar-beet seed farms in Europe. For information and courtesies extended on these

trips, the author wishes to express his thanks and high appreciation to Dr. Lewis S. Ware of Paris, author of "Sugar Beet Seed"; M. Philippe de Vilmorin, of Vilmorin, Andrieux & Co., sugar-beet seed growers, Paris; Mr. Ernst Giesecke, Director Clerc and Captain Troje of Rabbethge & Giesecke, sugar-beet seed growers, Kleinwanzleben, Germany; Mr. J. P. Dudok van Heel, of Kuhn & Co., sugar-beet seed growers, Naarden, Holland; Mr. M. Ritter von Wohanka, Dr. H. Briem and Mr. K. Rossam, of Wohanka & Co., sugar-beet seed growers, Prague and Yenc, Bohemia. The author also wishes to thank the following, who have reviewed portions of his manuscript: Dr. Harvey W. Wiley, who supervised the raising of the first commercial sugar-beet seed grown in America; Dr. Hans Mendelsohn, who for several years past has been in charge of extensive sugar-beet seed operations in Colorado, Nebraska, and Montana; Dr. C. O. Townsend, director of the sugar-beet seed experiments conducted by the United States Department of Agriculture, and Mr. W. K. Winterhalter, who manages large sugar-beet seed farms in Idaho.

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# INTRODUCTION

THE sugar beet is one of the most scientifically bred plants in the world. Other plants are bred for bulk or beauty or flavor, but the sugar beet is bred for its chemical constituents; not for the plant itself, but for its resultant product, sugar, which, by the aid of the light, is gathered wholly from the atmosphere at the under, outer edges of the leaves and from there is carried through the leaf and leaf-stalks and deposited in the root.

Beginning with a little scraggy, irregular-shaped plant which weighed but a few ounces, and in France yielded only 5.89 tons per acre in 1812, the botanical wizards have developed a large, regular-shaped, one and one-half to two pound root which in Germany, the greatest beet-sugar producing country, yields an average of about 14 tons per acre from 1,300,000 acres.

More important even than the increase in size has been the increase in sugar content. Originally containing but 4 to 5 per cent. of sugar, of which Achard in

1812 was able to recover 2.27 per cent., beets now contain 16 to 20 per cent. of sugar, 85 per cent. of which is recoverable. As a result of the increase of both tonnage and sugar content, Germany now harvests as much sugar from one acre as Achard harvested from 17 acres.

These results have been accomplished by the application of the most painstaking, patient, scientific labor, which for generations has been devoted to the breeding of sugar-beet seed and by the application of improved agricultural and manufacturing methods.

Botanists have succeeded in modifying almost every characteristic which the beet possessed at the outset, even to its habit of seeding and perpetuating its species. Originally an annual, as are many of the wild beets to-day, it sent up its seed stalks and produced its seed the year it was planted, but the early botanists trained it to devote all of its energies the first year to developing its root and to delay its reproductive labors until the following season.

To cause it to produce seed, the root is dug in the fall and laid away where it will neither freeze nor heat and when replanted in the fields the following spring it sends up its seed stalks; the seed is ready to harvest in the autumn.

A few obstinate plants occasionally revert to the former habits of the race, and these are useless for breeding purposes, but with the great mass of them the biennial seeding characteristic has become fixed. That it still has a high regard for its ancestry is evidenced by the fact that if by chance the seed from an annual beet be planted, it produces an enormous proportion of annuals, which are of inferior value even for factory purposes.

As an annual, it ceased to grow and to gather sugar by the middle of the season and, to feed and nourish its seed stalks and seed, it began to use up the sugar it already had gathered. The result was that when autumn came, the exhausted fibrous roots contained but little sugar; the only valuable portion was the seed. Due to the skill of the plant wizards, it now devotes all its energies the first year to developing a large handsome root and storing it with sugar, the gathering of which continues to the harvest time, storing sugar even after the root has ceased to grow.

The well-shaped, high sugar content beets which are destined for breeding purposes the following year, if they measure up to the fixed standards, are known as "mother beets." They are dug in the fall, siloed and examined during the winter and planted the fol-

lowing spring, when they put forth their seed-stalks and yield their seed in the autumn, a year and a half from the time the seed originally was planted.

As an annual, little or no opportunity was given to the botanist, and none to the chemist, to study the characteristics of the beet, for the growth of the root is impeded if tampered with during the growing season. Having been trained to defer its seeding until the second year, the botanists and chemists are given a free rein and a golden opportunity to examine with the utmost minuteness every physical and chemical property of both the inside and outside of the root, before determining whether or not to replant it the next spring and allow it to go to seed.

As a result, both the weight and sugar content of the beet have been increased several hundred per cent., and so valuable has it become for sugar-making purposes that it supplies one-half the sugar of the world, an economic blessing to the people who consume sugar and wish to purchase it as cheaply as possible.

But the change in the habit of seeding is only one of many changes which have been effected in the character of this plant. Indeed, scarcely an original characteristic has been left it, aside from the fact that it still grows with its leaves in the air and its root in the ground.

During the last century, the botanists have not only changed the color of the neck of the beet from red to rose, from rose to gray, from gray to green and from green to white, but they have changed the color of the beet itself from red to white, back to red and finally back to white, its present color.

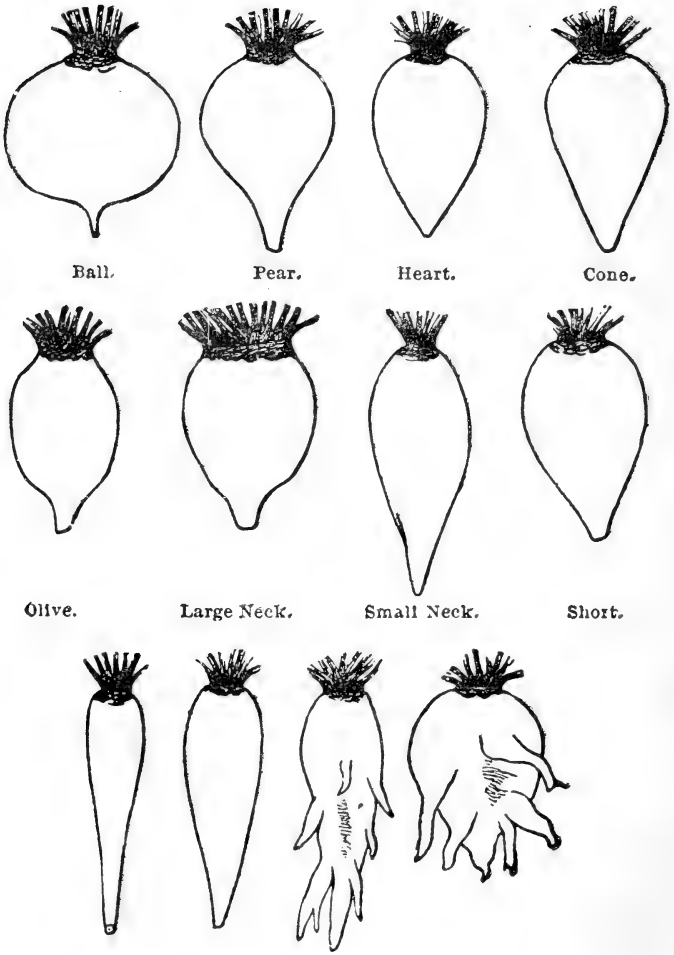
They trained it to bury itself and grow entirely beneath the surface of the soil. They then changed their minds and trained it to grow as much above as beneath the soil. Finally they led it back and caused it to grow entirely beneath the surface with only the leaves and crown exposed to the air.

The texture of its skin and of the root itself has undergone a marked change, as has also the proportion of sugar to the other solids in the root.

The number of its leaves, their shape, their veins, their shade, their position and the length of their stalks, all have been modified by the botanist.

As to shape, they have been made to outdo all the acts of a contortionist, having assumed no less than eleven different shapes in a little over a half century, as will be noted from the following illustration, reproduced from Dr. Lewis S. Ware's "Sugar Beet Seed."

To-day, pivoting or slender shapes are used exclu-




TYPES OF BEETS

From "Sugar Beet Seed," by Dr. Lewis S. Ware, Orange Judd Co., Publishers.

sively for factory purposes, though some of the other shapes still are used for stock beets.

In bringing the sugar beet to its present degree of perfection, the study has been the quicksand in which have been buried more promising hopes and theories than have gone down with scores of other plant studies. But in working out every known theory concerning each characteristic of this pliable plant, the chaff has been separated from the wheat and the sugar beet has become one of the valuable crops of the world.

# SUGAR-BEET SEED

## Its History and Development

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### OBJECTIVES AND PROBLEMS

**Beta Vulgaris** is one of many hundred varieties of the family to which the sugar beet belongs and it is identified botanically with the ordinary garden beet. It is known to have existed and to have been used for food since the time of the Romans, but through special selection and culture during recent years, various characteristics, such as shape, size, color, texture, and the character of the foliage have become fixed.

No special interest was centered in the beet until the publication in 1747 of Marggraf's pamphlet, in which he set forth his discovery that the beet contained a small quantity of true cane sugar, of which he had succeeded in recovering a quantity of crystals.

In 1799, Achard, a pupil of Marggraf, presented to

the King of Prussia a few pounds of sugar which he had succeeded in producing from beets, with the result that in 1801, the King financed for him the erection of a small factory in Silesia, the first beet-sugar factory in the world. Of all the beets experimented with by Achard, the White Silesian gave the best results and this variety has been used for breeding purposes by seed growers throughout Europe.

Vilmorin, of France, originated the idea of selecting beets according to quality and therefore is the father of modern beet breeding. At an early date, he commenced growing beets by selection, but it was not until 1830 that his work assumed real proportions, after which the improvement was rapid and soon was taken up at Quedlinburg, in the Province of Saxony, Germany.

Vilmorin's first method of selection was by specific gravity, a method which had been in use in Germany for testing potatoes. Whole beets were dipped in a salt solution of certain strength. The beets which floated were rejected, while the heavier beets, which sank in the brine, were selected, it being presumed that they were universally higher in sugar content.

Although it later was found that the specific gravity of the beet was not correlated to the percentage of

sugar in the beet, Vilmorin made such progress in increasing the sugar content of the beet, that in 1837 the "Vilmorin Original" seed sold at 25 to 75 cents per pound, as compared with $6\frac{1}{2}$ cents for Quedlinburg seed. In 1850 he published his pamphlet on increasing the sugar content of the beet, and in 1856 he began to breed by selection and to take note of the texture of the skin. It was then that, for the first time, the question of creating a new variety was discussed.

Meanwhile, the polariscope had been invented, by which the sugar content of the beets could be tested with mathematical precision. This instrument in its present form was built by Ventske, who pointed out the use of the instrument for seed beet selection in 1851, after which Vilmorin adopted it, followed by Rabbethge & Giesecke in 1862.

In 1859 Rabbethge & Giesecke established a sugar-beet seed farm at Klein Wanzleben, near Magdeburg, which since has grown to be the most extensive sugar-beet seed enterprise in the world, comprising 13,000 acres in Germany and Russia and employing several million dollars of capital. The following year, 1860, this firm commenced to breed a new type of beet which has been strictly adhered to ever since, and to-day the standard brands of beet seed of the world are a

combination of the "Vilmorin Original" and the German "Klein Wanzleben." *

*All the great plant breeders who have devoted their lives to the amelioration of the beet seem to have contented themselves with breeding from some variety of the garden beet, of whose early ancestry or origin they know nothing. Ages before, the garden beet was bred up from the wild beet, and the early selections of the wild plant may or may not have been the best from which to breed for sugar-making purposes. It seems strange that, so far as appears, no attempt has been made to breed sugar beets from some of the numberless varieties which grow on the shores of the Adriatic and Mediterranean seas. Dr. Townsend, Pathologist of the U. S. Department of Agriculture, has made some preliminary experiments in this direction and has secured some remarkable results, securing fairly good-sized, well-shaped beets the first generation, which yielded 14 per cent. of sugar.

The European breeders labored for several decades before they succeeded in bringing the garden beet up to 14 per cent. sugar, and it is possible that from some of the wild varieties a yield will be obtained which will astonish the world.

Another surprise may come from seed grown in Alaska, some sections of which have a summer warmth which corresponds with that of Washington, D. C. The vegetables there produced are of a very superior quality. As the leaves of the beet gather sugar from the atmosphere by the aid of the light, it seems reasonable to suppose that in a latitude where in the growing season, the light is continuous, the extra quantity of light may materially increase the quantity of sugar which the leaves will gather. Experiments with sugar-beet seed soon will be made in Alaska.

## BREEDING NEW TYPES

The process of breeding new types of sugar beets usually is as follows: Some one variation from the usual is noted in an individual beet or in a family of beets. These beets then are photographed and the seed from each "mother" or the outcome of a group of "mothers" is kept separate and grown separately for successive generations. The selected "mother" first is planted, her seed is sown and the resultant roots are selected, all which differ from the original "mother" being thrown out. By modifying the variations in sugar content, size, shape, leaves, etc., a new family or strain is created, the characteristics of which will be transmitted through several generations, thus attaining one of the main objects, which is constancy. Oftentimes, after the expenditure of years of effort, the accidental introduction of one poor seed beet spoils a whole family.

Nor can the painstaking work cease after the characteristics of a family have become fixed, for while the beet has a tendency to resemble its parent, it may revert at any time and resemble some early ancestor. Any departure from the regular yearly methods of selection and regeneration will cause it to revert to a lower form

and, to maintain the purity of the blood, it is constantly interbred with new standard varieties.

The work is infinite and must be continued year after year, generation after generation, and century after century, so long as beets continue to be grown for their sugar product.

Beets resemble the human species, in that the best results are to be obtained neither by breeding too closely as with the marriage of cousins, nor by intermingling races. Knauer maintained that all existing varieties of sugar beets came from one of five starting points: 1st, Belgian; 2d, Quedlinburg; 3d, Silesian; 4th, Siberian; 5th, Imperial beet.

The problem in beet-seed culture is to breed a seed which will produce beets that not only will be satisfactory in sugar content and tonnage, but which will give like or better results from year to year. In the early stages of the work, this quality was lacking; sugar factories could not depend upon either tonnage or sugar content.

European beets have been tested running 20 and even 22 per cent. sugar, but experiments in breeding made with these very high testing beets have resulted in comparatively inferior roots. Inasmuch as when the approximate state of perfection has been reached in

plant breeding, an increased tendency to revert appears, the invariably discouraging results secured from breeding these extraordinarily high sugar content beets have led many to believe that, so far as Europe is concerned, the limit of perfection has been reached in breeding sugar-beet seed by methods heretofore used and that the most that can be accomplished by these methods is to reach and maintain the high standard which has been reached by the leading growers.

Some seed growers have attempted to produce a different seed for each character of soil, as well as for different climates, but except where the difference in soil or climate is marked, these efforts have not met with success.

At one time, claims were made that certain seeds would mature a month earlier than other seeds; these claims were found to be fallacious. Some leading seed growers of the world market three varieties of seed: one which is high in sugar and low in tonnage, one which is high in tonnage and low in sugar, and one which is moderately high in both sugar and tonnage. But so closely do all the brands of any grower approximate his other brands that when the supply of one runs short, it is surmised that orders for it are filled by substituting his other brands.

While there are and always will be great differences in expertness, there are no secrets in the breeding of sugar-beet seed. The conditions which cause variations are known, as are also the meaning of the various characteristics of the foliage and of the beet itself. A proper appreciation of the importance of these conditions and characteristics, coupled with methodical, careful attention, will bring results which will differ only because of the degree of expertness of those engaged in the work, and a knowledge of essential facts which only can be ascertained after years of systematic work.

## SUPER-ÉLITE, ÉLITE, AND COMMERCIAL SUGAR-BEET SEED

Sugar-beet seed is divided into three classes: super-élite, élite, and commercial. Both the élite and super-élite seed are the seed obtained from laboratory mother beets which have successfully passed every physical and chemical examination to which they have been subjected. The seed from those mothers which were truest to type and yielded the highest results in their various examinations is kept separate from all other seed and is used for breeding purposes. This is known as "super-élite" seed and is never sold. It is priceless.

Whatever value has been acquired by years of patient scientific work on the part of the seed grower is represented by this super-élite seed, which easily might be worth $250 to $1000 per pound.

The balance of the seed from the original laboratory mother beets, all of which had to pass the various examinations successfully, but which tested slightly lower in some characteristic than did the mothers whose seed was selected to be used for breeding purposes, is known as "élite" seed. This élite seed is used to grow a crop of "stecklinge" mothers, or "stick" mothers, so named because of the fact that the seed being planted and allowed to grow thickly, the beets grow long and slender, and these "stecklinge" mothers could be planted by pressing a pointed stick into the well-prepared ground, and after removing the stick the beet could be inserted in the hole.

Commercial beet seed is the product of the "steckling" mothers, thus commercial beets are two removes from the original laboratory beets, which are their grandmothers.

## TIME REQUIRED IN WHICH TO PRODUCE SUGAR-BEET SEED

Starting with a certain strain of seed from which to breed, five years of painstaking, scientific work are required before the resultant crop of commercial beets is harvested.

**First Year.** Say that in the spring of 1916, the original selected and pedigreed super-élite seed is planted. In the fall, those of the beets which pass the physical selection of both foliage and root and a chemical test of the root, are siloed or placed in cellars for the winter, where they are kept from frost and from heating. These are known as "mother beets."

**Second Year.** In the spring of 1917, these mothers are uncovered and, after passing a second chemical test, are planted in the field and in the fall yield a crop of élite and super-élite seed. As the super-élite seed is withdrawn and used for breeding future generations of élite and super-élite seed, it does not continue in this calculation.

**Third Year.** In the spring of 1918, the "élite" seed is planted closely in order to grow a crop of long thin beets called "steckling," which are gathered in the fall and preserved in siloes until the next spring.

**Fourth Year.** In the spring of 1919, the "steckling" are planted and in the fall they produce a crop of commercial seed which can be planted in the spring of 1920, producing beets from which sugar is extracted in the fall of that year, five years from the time the scientific work began.

## DISTRICTS WHERE GROWN

The territory which is adapted to the production of sugar-beet seed is much more restricted than is that which is adapted to the production of commercial sugar beets. Climatic and soil conditions which may be excellent for the production of factory beets, more often than not are unsuited for the production of sugar-beet seed.

Germany produces more sugar-beet seed than does any other country and practically all of it is grown in the Province of Saxony, where the best sugar-beet seed land sells at from $600 to $1000 an acre. Russia, the next largest producer of seed, has two important seed districts, one in Poland, one about Kieff. Nearly all of the French seed is produced in the Departments of Nord and Aisne; the Austrian seed is produced in the Provinces of Bohemia and Moravia. Smaller quantities are produced in Italy, The Netherlands, and Brabant, Belgium. In the United States, considerable

quantities of beet seed are produced in Utah, Idaho, Montana, and Colorado, and a small quantity in Michigan.

But even where soil and climatic conditions are favorable, only a small portion of the land can be devoted to growing sugar-beet seed. The flower is not a self-fertilizer, but is rich in pollen and is fertilized from the pollen of other neighboring beet flowers. As the pollen is carried great distances by the wind and the plant suffers from atavism, beet-seed farms must be widely separated, else hybrid beets result. It is not safe to have breeding fields located within a half a mile of each other, as one low-grade beet going to seed in the midst of selected seed beets will so affect its neighbors as to destroy the value of the surrounding seed for a considerable area.

## SOIL AND FERTILIZATION

Even where climatic conditions are favorable, it was thought at one time that this highly organized plant would not yield as good results on flat land as on hill sides, especially those with a southern exposure, but in recent years it has seemed to do equally well on flat as on hilly ground.

As to soil, the mother beet is most exacting, both as

to character and richness, for it can supply but one-tenth of the potassic and lime salts which are needed for the seed; the balance is drawn from the soil.

By scientific fertilizing, inferior soils frequently are brought to such a state of productiveness that this discriminating plant will thrive, but until such time is reached, only the richer, and sometimes irregular sections of a field are devoted to mother beets, and the poorer portions are devoted to other crops.

As the rows of beets are made to run around oblong, triangular and irregularly shaped patches of inferior soil, the fields have the appearance of having been planted in a very haphazard manner, but when one examines the soil map, he discovers that the field is planted in exact conformity with the map.

Simply to "fertilize" the soil does not meet the requirements. It must be "scientifically fertilized," else the resultant seeds are more subject to the attack of parasites and micro-mushroom ravages.

In order to develop the plants as quickly as possible, the soils are provided with ample quantities of phosphoric acid, potash, nitrogen, lime and magnesia. On the seed farm of M. Legras, in Aisne, France, as noted by Dr. Ware, were many different kinds and qualities of soil, all of which eventually were brought to a state

of perfection by scientific fertilization and intense cultivation. Since raising his soils to the desired state, M. Legras annually uses nearly 3500 tons of fertilizer on his 750-acre farm. The amount of study, research and scientific experimentation which has been devoted to this work readily can be understood by noting the kinds and proportions of fertilizer M. Legras uses, which are as follows:

| | | | Per Cent. |
|---|---|---|---|
| 1760 | tons | of barnyard manure | 50.58 |
| 950 | " | defecation scums from beet-sugar factory | 27.30 |
| 220 | " | leaves and necks of beets | 6.32 |
| 161 | " | woolen waste | 4.63 |
| 108 | " | furnace slag | 3.10 |
| 60 | " | oil cake | 1.72 |
| 60 | " | phosphate | 1.72 |
| 52 | " | sodic nitrate | 1.50 |
| 30 | " | fish guano | 0.86 |
| 24 | " | potassic chloride | 0.69 |
| 21 | " | double phosphate potassium and magnesia | 0.60 |
| 15 | " | sulphate of ammonia | 0.43 |
| 10 | " | dried blood | 0.29 |
| 9 | " | super-phosphate | 0.26 |
| 3480 | " | | 100.00 |

## PLANTING SUPER-ÉLITE SEED FOR GROWING "MOTHER BEETS"

Sandy loam soils offer the least physical and chemical obstacles for developing uniform beets, true to type, and hence are preferred to the heavier clay soils. The soils of the fields used for growing the selected super-élite seed are placed in excellent chemical and physical condition. They are fertilized scientifically and worked thoroughly to great depth until the best garden conditions have been attained.

To avoid errors resulting from local conditions, field trials of selected strains of beet seed, to be planted for the purpose of breeding "mother beets," are conducted on more than one farm, and oftentimes in more than one section of the country.

Ten or twelve pounds of the super-élite seed is required for each acre. It is planted by hand or by drills and covered to a depth of $\frac{3}{8}$ of an inch. As there still is a diversity of opinion regarding the most desirable size of mothers, and as the closer they grow the less size they attain, the spacing varies from $8 \times 8$ to $12 \times 12$ inches.

The spacing demands experience and cannot be conducted by ordinary field workers. The cultivating and

PLANTING MOTHER BEETS FOR SEED

After the land has been thoroughly sub-soiled and prepared, the planting is done by a gang of 27 men, consisting of 1 foreman, 1 driver, 1 shoveler, 6 men with apron bags to drop beets in rows, 6 men on hands and knees to place beets in soil, 12 men to tramp ground around beets.

hoeing is frequent and thorough until such time as further field work would injure the leaves.

Any roots which miss or show degeneracy either are replaced by other beets specially grown for this purpose, or by turnips, in order that all will receive a like amount of nourishment. If at harvest time any vacant spaces are found, the surrounding beets are weighed and 50 per cent. of their weight is deducted, as it has been shown by careful experiments that they increase to that extent by reason of being isolated.

## FIRST PHYSICAL SELECTION

Having planted super-élite seed in the spring and grown the beets to maturity, in October the first physical selection, which has to do with the foliage, is made. The expert, and he must be a trained and discriminating expert who has devoted years to the work, goes slowly through the field, row by row, placing a stake beside each beet the leaves and crown of which meet his approbation. It may be one in twenty-five, or one in a hundred—he misses none which reach the standard; he stakes none which are not up to standard.

As by the aid of the light, the sugar is gathered from the atmosphere by the outer under edges of the leaves and from there is carried down and stored in the root,

the leaves play an important part in the elaboration of sugar and no detail is too small for consideration.

Beets with very small or deformed or badly-shaped leaves are not selected for mothers. Oblong leaves indicate higher sugar content than round leaves and pointed leaves always are low in sugar.

If the leaf has a large nerve in the center, without intersecting nerves, the beet is low in sugar. Three central nerves and partially developed cross nerves are what is desired. The wrinkles on the leaves indicate sugar—the greater the number the higher the sugar content. Dark, rather than light-green leaves are sought; reddish leaves indicate a beet of poor quality. The texture and fringes and the length of the leaf stalks all have a meaning to the expert who is breeding to create or perpetuate an individual type. Outspreading leaves indicate more sugar than upright leaves where the sun cannot reach their surfaces as readily, but if the leaves lie too flat, they will be broken off with the cultivator and thus cease to perform their function of gathering sugar.

The percentage of sugar increases with the number of leaf-circles, of which there should be not less than eight. One of Pellet's observations, made with Vilmorin seed, was as follows:

| Number of Leaves. | Per Cent. Sugar in Beet. |
|---|---|
| 42 | 15.7 |
| 39 | 14.8 |
| 31 | 13.8 |
| 23 | 12.2 |
| 19 | 11.7 |

The size of the crown of the beet also is noted, for it must be neither too large not too pinched.

It required generations of study and experimentation to be able to read these and numerous other signs which indicate the breeding qualities desired of a beet, but now they are as an open book to the trained eye of the expert who stakes the beets whose foliage and crown meet his approbation.

## SECOND PHYSICAL SELECTION

Having passed their first physical selection, the beets which are staked and are destined for "mothers" are carefully dug, when the roots themselves are examined as carefully as were the leaves. They must be of good size and length; not too short or their radicles will not draw sufficient moisture and nourishment from the soil; not too long and slender or they will lose their tips when plowed out. If the taper begins near the top, the tonnage will be low; they

must be of good size for a considerable distance below their point of greatest diameter.

The texture and color of their skin are important considerations; the tougher the skin, the richer is the beet in sugar.

Two spiral depressions always should extend from the neck down, filled with a hairy growth, as the hairs aid in extracting from the soil the maximum amount of plant food.

They should be as regular as though made in a mold. Irregular shaped beets are not easily cleaned, the adhering dirt dulls the beet knives, hence the slicing is poorly done, the cossettes do not give satisfaction in the diffusion battery, and owing to the dirt the juices are impure.

The beets which pass the second physical selection are tagged with a card bearing a number and printed form upon which each mark of the pedigree and qualities can be noted in detail, and each beet is photographed.

The leaves are removed, weighed and the weight is noted; the beets selected are carefully laid away. The other beets are dug and used for making sugar. In November and December a further physical examination is made of the beets which have been selected for mothers. After passing through an automatic

washer, they are spread in a slightly warmed room to dry and to afford convenient study of shapes, color and texture of skin.

Beets which fail to meet every requirement are sliced and used for sugar. Those which are selected are weighed on a self-registering scale, after which they are carefully laid away.

Carefully as were made the selections in the field, but 5 to 8 per cent. of the beets which are staked in the field ever pass these subsequent examinations and reach the chemical laboratory, in which a large percentage of those which have met the physical requirements are rejected.

## FIRST CHEMICAL SELECTION

As when medicine fails and the human patient is placed upon the surgeon's operating table, so these Adonis-like beets which have had every part of their exteriors examined with microscopic thoroughness now must have their interiors opened, examined and analyzed, for the physical points of the outside are but indications of what the interiors contain, the latter being the chief consideration.

The composition of the beet should be uniform,

as that facilitates the manipulation of the juices in factory treatment. When sent to the laboratory, each beet has a vertical hole drilled into it reaching to the center, and the extracted pulp is weighed and divided into not less than three samples, each of which is analyzed. The laboratory tests give the per cent. of sugar in the beet and in the juice, the dry extract of the juice and the purity coefficient or solid substances other than sugar.* To prevent de-

*In the juices of the beet are many salts, or solids, in solution. The solids, other than sugar, are called impurities and these impurities act as a resistant to the process of extracting the sugar. As the sugar and other solids are made in the field and not in the factory, it is important to know the proportion between sugar and total solid substances and to breed for higher sugar content. If a beet contains 18 per cent. of solid substances, of which 16 per cent. is sugar, then $\frac{16 \times 100}{18}$ = purity coefficient = 88.8. Not less than 80 per cent. of the solid substances should be sugar. In 1915 the average purity coefficient of beets grown in California was 82.65; Colorado, 84.84; Idaho, 87.14; Michigan, 84.08; Utah, 85.06. In Germany, the purity coefficient rarely falls below 87 and frequently exceeds 90, and therefore from a given grade of beets showing a like polarization, the extraction of sugar per ton of beets is greater in Germany than in the United States. In a technical article in "The Beet Sugar Gazette" of July, 1901, the writer states the effect of impurities

terioration, the holes made by the rasp are filled with clay or sprayed or sprinkled with charcoal.

In one establishment, 60 people make as many as 10,000 analyses every twenty-four hours. To avoid injury, the beets which pass this examination and are destined for breeding are carried in specially-constructed baskets, cleaned of any adhering dirt and laid in rooms on portable tables, usually 50 beets to a table, where they are examined a second and sometimes a third time, for checking purposes; the selection labors continuing through January, February, and March.

on the extraction which can be secured from a 12 per cent. beet to be as follows:

| Sugar in Beet. | Purity. | Yield. | |
|---|---|---|---|
| | | Molasses. | Sugar. |
| 12 | 70.0 | 5.12 | 6.00 |
| 12 | 72.5 | 4.45 | 6.67 |
| 12 | 75.0 | 3.82 | 7.29 |
| 12 | 77.5 | 3.25 | 7.87 |
| 12 | 80.0 | 2.70 | 8.42 |
| 12 | 82.5 | 2.19 | 8.93 |
| 12 | 85.0 | 1.70 | 9.42 |
| 12 | 87.5 | 1.24 | 9.88 |
| 12 | 90.0 | 0.80 | 10.32 |

*Footnote continued on page 24.*

All roots grown from any one sample of seed and which prove to be not as uniformly high in sugar content and purity as were the original beets from which the seed was raised are discarded. Less than one-half of one per cent. of the roots tested are found to be suitable for breeding purposes.

After this chemical selection of a breeding family, the beets which meet the requirements are inspected by the botanist and sugar content and purity are considered in connection with shape and other external qualities. Then they are laid away in siloes or cellars which protect them from heating and freezing, and in the spring they receive their final test.

The same writer gave the following progress in the improvement of the beet in The Netherlands:

| Years. | Sugar. | Purity. |
|---|---|---|
| 1892–93 | 11.88 | 84.60 |
| 1893–94 | 12.69 | 85.30 |
| 1894–95 | 12.12 | 85.0 |
| 1895–96 | 13.79 | 87.2 |
| 1896–97 | 13.24 | 87.4 |
| 1897–98 | 14.33 | 87.9 |
| 1898–99 | 15.13 | 87.8 |
| 1899–1900 | 14.65 | 87.3 |

## SECOND CHEMICAL SELECTION

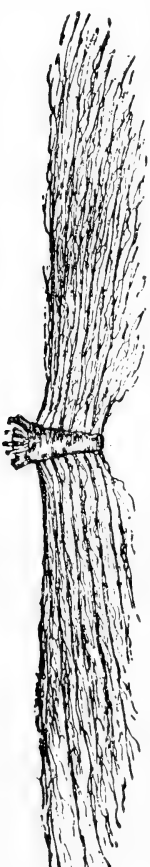
Although having had their every exterior and interior characteristic examined with persistent minuteness, some growers submit these wounded, battle-scarred "mothers" to still further mutilation and examination the following spring, before they are permitted to reproduce.

As they are taken from the silo in the spring, a second sample is taken from a hole bored diagonally through the center of the root and tested in the polariscope to determine the quantity of sugar lost during the winter. If the loss does not exceed a given amount, the "mother" receives her diploma and when the season opens is planted for seed.

Before planting, every observation, test, and measurement which has been made of the mothers by the botanists and by the chemists in their various examinations is carefully written up in their individual pedigrees, which are attached to the photographs for use and reference in after years when breeding new families, in order to be sure that the physical and chemical characteristics are retained.

One large concern which claims to have the records and photographs of each and every mother beet it

has planted during the past 25 years produced from their vaults almost instantly the complete detailed record and the photograph of every number of mother beet called for.



"Mother" with Top and End Removed, Showing the Hairy Growth and Ramifications after Three Months from Time of Planting

From "Sugar Beet Seed," by Dr. Lewis S. Ware, Orange Judd Co., Publishers.

## PLANTING AND CULTIVATING SELECTED "MOTHER BEETS"

Still handled carefully to avoid injury, the "mother beets" are conveyed to the fields, where they are planted by hand $3 \times 3$ feet, each having an area of 9 square feet from which to draw its sustenance. That they need all this space can be seen from the accompanying illustration, reproduced from Dr. Lewis S. Ware's "Sugar Beet Seed."

The radicles of a "mother beet" frequently extend for a distance of three feet in every direction and thus when planted only three feet apart, the roots interlace and

draw nutriment from every cubic inch of soil to a depth of several feet.

These "mother beets," which have passed every scientific examination to which they can be subjected by the botanist and the chemist, are of great value. Not only are they carefully guarded from theft, but to secure the maximum amount of mature seed from a given quantity of mothers, wherever practical the "mothers" are dismembered and planted in several places.

Nine square feet of soil only will nourish a certain number of seed stalks. A large "mother" sends up a great number of seed stalks and forms more seed than can be matured. Suppressing a portion of the stalks was tried, but the efforts were futile, and so, except where the "mothers" are small, they are dismembered.

Where the "mothers" are small, a whole one is planted in each three-foot square, but where the mothers are large and have a great number of leaf eyes, they are sliced vertically, sometimes into as many as twenty pieces, care being exercised to see that each segment contains a sufficient number of leaf eyes to furnish the requisite number of seed stalks. The wounds are dressed with an antiseptic and one segment is planted in a place. Thus one mother may be made

to produce several times the amount of seed which it would produce if planted in one place. Because of liability to attack by insects and disease, mothers never follow a crop of beets.

After planting, the "mothers" are cultivated every few days until the foliage becomes so luxuriant as to prevent further field work. The seed stalks frequently are five feet high.

The seed ripens in the autumn, but the seed on all the seed stalks of one beet does not ripen at the same time; thus it is necessary to go through the fields several times, selecting and cutting the stalks on which the seed is ripe.

The stalks of the "mothers" which have been selected to produce super-élite seed with which to perpetuate the breeding, are tagged with the corresponding numbers which had been assigned to their "mothers" and after they have been dried, the seed of each mother is removed from the stalk and placed in a separate bag bearing the number of the "mother." After the seed is harvested the mother roots are removed from the field to prevent breeding insects.

The balance of the seed from the original selected laboratory mothers is known as "élite" seed and is estimated to cost from $4 to $10 per pound to produce.

A 1916 shipment to the United States of 50 bags of élite seed (110 lb. per bag) was insured for $50,000, or nearly $10 per pound. Élite seed is never used for producing a crop of commercial seed, but to grow a crop of long slender "mothers," called "steckling," which, in turn, produce the seed of commerce. Thus commercial beets are not the children, but the grandchildren of the "mothers."

## PLANTING "ÉLITE" SEED

"Élite" seed for the production of "steckling" is drilled in rows usually 16 inches apart, using 10 to 12 pounds of seed per acre.

The plants sometimes are thinned to one inch apart in the rows and are cultivated the same as are commercial beets. The roots grow deep in the ground, but only to one or one and one-half inches in size and weigh from two to ten ounces.

The dwarfing of the diameter of the roots, caused by growing closely in the rows, hastens their ripening, thus affording a longer time for hardening, prior to harvesting, in consequence of which they keep better through the winter.

Before harvesting, all the roots which throw up any

seed stalks are removed. One acre of "steckling" will produce enough beets to plant many acres for seed. It is customary to defoliate, or remove the leaves, of the "steckling," after which they are carefully siloed in pits from 15 inches to 3 feet deep, by 3 to 4 feet wide, where they are protected from heating or freezing by soil covering of the required depth.

## GERMINATION TESTS

As soon as any of the seed has ripened, the germination tests are begun. Of each average sample of seed, two tests are made for determining its germinating power. To make this test, the seed frequently is soaked from six to fifteen hours in sterilized water in a room of 68 to 75 degrees Fahrenheit, after which it is pressed into a germination bed.

One method of testing is as follows: Germination beds are made of sand, to which moisture is added to the extent of 60 per cent. of its water-holding capacity. Deep plates are partially filled with saturated, sterilized sand, and with an instrument resembling a pill machine, 100 indentations are made in the sand of each plate. One beet ball is dropped into each indentation, and the sand is smoothed over them. Over each pan is

placed a glass cover on which is recorded the kind of seed, together with the date of planting and the weight of the filled receptacle, after which it is placed in a room which is kept at a temperature of 70° F.

For checking purposes, all tests are made in duplicate. The plates are weighed daily and sufficient weight of water is added to renew the loss by evaporation.

The germination rooms are kept at an even, exact temperature during the day, sometimes slightly raised at night. After having been placed in the germination bed, the balls which have germinated are counted and noted daily, and the germs are removed. After removing the germs these balls are sometimes placed in another germination bed. Those which have not germinated remain in the original bed.

At the end of seven days, 70 per cent. of the required number of germs must have germinated, and the total required number must have germinated by the end of fourteen days.

## HARVESTING, THRESHING AND CLEANING SUGAR-BEET SEED

As with the seed from selected mother beets, the seed which grows from the steckling ripens unevenly, that on some stalks being ripe while on other stalks from the same beet the seed is quite green. This necessitates going over the fields several times.

As the stalks are cut, they are stacked in bundles to dry, after which they are threshed with an ordinary threshing machine in which the speed of the cylinder has been reduced. The seed then is conveyed to storage warehouses. The weight of seed and stalks per acre runs from two to six thousand pounds, which yields from 1200 to 2500 pounds of seed. In Germany the yield is 1600 to 1800 pounds; in Russia, 1200 to 1400 pounds.

In the warehouses the seed is passed over vibrating sieves to remove the dirt, weed seed, and very small beet-seed balls, and through winnowing machines, or fanning mills to remove the dust, blossoms, and light, undeveloped seed. Ordinarily, it is an easy matter to remove all but a small fraction of 1 per cent. of the inert matter, but as the "Magdeburger Normen," under which the seed is sold, allows 3 per

HARVESTING SUGAR-BEET SEED

cent. of dirt to be sold as seed, the grower usually regulates the cleaning so as to leave in the seed $2\frac{7}{8}$ per cent. of dirt, thus complying with the fixed standard and getting paid a good price for a considerable quantity of dirt.

After being cleaned, the seed is carried by machinery over stalk-pickers, inclined endless belts of cloth, from which the seed rolls away and to which the remaining seed stalks cling and are carried to a chute.

After the seed has been cleaned, it is tested for moisture, which, under the "Magdeburger Normen" must not exceed 15 per cent. of the weight of the seed. If the moisture exceeds 15 per cent., the seed is dried, usually by artificial dryers, and again the grower is careful not to remove any more moisture than is necessary to comply with the fixed standard. With the moisture below 15 per cent., the seed will keep for five years.

The " Magdeburger Normen" fixes a standard for germinating power and any seed which does not reach this standard can be thrown back on the grower. If old seed falls below the standard fixed, to render such seed salable, it is blended with seed of higher germinating power, after which it is packed in double

THRESHING SUGAR-BEET SEED

General View of Plot of Seed Beets
Showing muslin covers on selected plants.

$5\frac{1}{2}$ bushel bags, containing 110 pounds, and stored for shipment.

## PURCHASERS' GUARANTEE

The standard fixed for sugar-beet seed is known as the "Magdeburger Normen" and seed growers generally guarantee their seed to be up to this standard, which is as follows:

(1) Dry substance, 85 per cent., that is, not over 15 per cent. moisture. If over 15 per cent. and not exceeding 17 per cent. moisture, deduction in price must be made for the missing dry substance. If over 17 per cent. moisture, seed can be rejected.

(2) Seed shall be 96 per cent. pure, that is, 96 per cent. of seed balls which will not pass through a 2-mm. slit sieve, but seed of 94.5 per cent. purity is furnishable if the purity below 96 per cent. is allowed for at its proportion of the purchase price. If less than 94.5 per cent. pure, seed can be rejected.

(3) Germination power must be, per kilogram (2.2 lb.):

(*a*) In case of large seed-ball seed, 60,000 germs;

(*b*) In case of medium seed-ball seed, 65,000 germs;

(*c*) In case of small seed-ball seed, 70,000 germs.

At least 70 per cent. of the required germs must have germinated within seven days.

The germination from 100 seed-balls within fourteen days must be not less than:

(*a*) In case of large seed-ball seed 80 seed-balls;

(*b*) In case of medium seed-ball seed 75 seed-balls;

(*c*) In case of small seed-ball seed 70 seed-balls.

By large seed-balls is meant seed which contains not more than 40 seed-balls per gram; medium, 41 to 50 balls; small, 51 or more seed-balls per gram. One hundred seed-balls should give not less than 125 sprouts in seven days and 150 sprouts in fourteen days.

It will be observed from the above that no guarantee is made covering either the sugar content, purity or tonnage which can be expected from the seed. For these results, the purchaser must rely upon the reputation of the seed grower and upon his experience with the various brands of seed which have been planted upon the character of soil where his factory is located.

Laxity on the part of a grower means a variation in the results which can be obtained from his seed; even a slight decrease may cause a loss of many thousands of dollars to a factory.

The average yield of beets in the United States is about 10 tons per acre, and to grow this acre of beets, 20 pounds of seed is used, or 200,000 pounds to plant 10,000 acres. A difference of 1 cent per pound in the price of the seed would amount to 20 cents per acre or $2000 on 10,000 acres. But when difference in price means even a slight lowering in the quality of seed, an apparent saving of $2000 would in reality mean a material loss.

ISOLATED SUGAR-BEET SEED

Seed beet covered with wire cage and tall muslin bag to give ample room for growth of seed stems and prevent overcrowding of racemes.

The variation in results secured from two good, but varying brands of seed might easily amount to 1 per cent. in the sugar content of the beets or 200 pounds of sugar per acre, 85 per cent. of which, or 170 pounds per acre, is recoverable in the factory. Calculating the value of this sugar at 4 cents per pound, the loss in sugar would amount to $6.70 per acre or $67,000 on 10,000 acres, a net loss of $65,000 on the transaction.

The lower tonnage yield of the inferior seed easily might amount to one ton per acre; a loss to the farmers of $57,000, thus incurring a total loss of $112,000, offset only by a saving of $2000 on the price of seed.

At 4 cents a pound for sugar, a seed which produces a beet containing one extra per cent. of sugar is worth $33\frac{1}{2}$ cents per pound more than is the inferior seed. Such being the case, it is easy to understand why many of the great botanists, physiologists and chemists have devoted their lives to the amelioration of the sugar beet, and why sugar factories do not try to save money by purchasing any but what is represented to be the highest grade of seed.

In quality, the purchasers of beet seed may be deceived. The harvest may be poor, or the grower may be careless, or worse.

Words of warning emanating from authentic sources

have not been infrequent. In Monthly Consular Report No. 218, November, 1898, American Consul, Henry W. Diedrich, then stationed at Magdeburg, Germany, said in part:

"If I may express an opinion, based on my personal observation, it is that some of our beet growers should insist more than they have upon getting none but the best of seed, no matter what the price may be. * * * The first-class sugar factories of Europe buy none but the very best seed, grown from high-grade individual 'mother' beets, to distribute among the beet growers; thus not only maintaining the standard of their sugar beets as to quality and quantity, but also putting themselves in a position to compete in all markets of the world. This first-class seed is sold and delivered by the growers on board cars in the Prussian province of Saxony at from 8 to 10 cents per pound, which is a moderate price, considering the fact that it takes at least four years to get it into the market.

"There is also a second-class seed offered for sale in this country at from 5 to 6 cents per pound. This is commonly called the 'nachzuchtsamen,' being a seed produced not from the mother beets, but from the first-class seed mentioned above. This inferior grade, however, is not used by first-class sugar men in Germany, France, Holland, and Belgium, but most of it goes to Austria, Russia, and the United States. And this is the reason why I deem it my duty to call attention to the importance of getting only the very best seed obtainable."

After studying the question for years, Mr. J. E.

W. Tracey, Sugar Beet Expert of the United States Department of Agriculture, said in "Progress of the Beet-Sugar Industry in the United States" in 1902:

"The beet-sugar industry in now so well established in the United States that it would be poor policy to depend longer on imported seed, there being always a possibility that by failure of the crop, or for reasons political or owing to trade disturbances, the supply of seed may be cut off. Even if this possibility is regarded as remote, it is nevertheless true that American beet-sugar factories will never attain their maximum profit until there is beet seed especially produced to meet American conditions of soil and climate."

The following year the Secretary of Agriculture sent Mr. Tracey to Europe, where he spent five months on sugar-beet seed farms. The 1904 Year Book of the Department of Agriculture contained an article by Mr. Tracey on the "Disadvantage of Relying upon Foreign-grown Seed." Mr. Tracey said in part:

"While there are careful and painstaking growers in France and Germany, where the great bulk of the sugar-beet seed used in this country is produced, there are many who are not only careless in their methods but dishonest in their practice in handling sugar-beet seed. They pose as growers and claim to make extensive analyses every year of individual roots, whereas in reality they simply buy seed where they can do so most advantageously, regardless of its quality. A large proportion of the seed used

in the United States is furnished by such dealers, while the better class of German growers, who, through fifteen or twenty generations of plants, have conducted most careful field and experimental trials and annually spend thousands of dollars in testing individual roots and making records and photographs of them, sell but very little seed here. This is largely due to the lack of interest and failure on the part of the American seed-buyers in investigating the methods and establishments of those from whom they secure seed.

"The information one generally secures from sugar-beet seed growers, not only as to their own business, but as to that of their associates as well, is frequently unreliable. Exaggeration is very common, and it is frequently impossible for an outsider to reconcile the results of his own observations with the statements made, both in conversation and in print. Seed which is sold as having been grown in the most careful and scientific manner is often actually the cheapest and poorest grade of seed procurable. It consists of both new and old seed, which has been grown under widely different conditions of soil and climate, and is mixed together by specially constructed machinery. It is explained that the different lots of seed are mixed to insure an evenness both in the germination of the seed and in the quality of the crop. The absurdity of mixing all kinds and grades of seed to produce uniformity in the crop is evident.

"It is generally admitted that the sugar beet, being one of our most highly bred plants, is very susceptible to the influence of both climatic and soil conditions; hence seed should be used which was produced under the most favorable conditions for the production of beets best suited to each particular locality.

The best seed imported is raised for the most part under very similar climatic and other conditions, but it is sown here in America under all conditions and in all soils, in New York and Michigan, Nebraska and Washington, and in the arid and semi-arid regions of Utah and California. No single strain can be the best for all of these varied localities. We can never expect to secure the best results in our sugar-beet industry when we have such conditions in the seed branch of the business.

## IMPORTANCE OF GROWING SUGAR-BEET SEED AT HOME

"It is absolutely essential to success that we secure the best quality of seed, and past experience has conclusively shown that we cannot depend upon doing so from abroad. We must raise it ourselves, and in such a careful, scientific manner that it will not only be of the best quality, but will have such characteristics as will make it adapted to the particular needs and requirements of the locality where it is to be sown. Seed raised on a particular soil and under certain climatic conditions may not be best suited for planting in like soils and under similar climatic conditions; in fact, very often it is not. Seed from comparatively poor soil may do best on rich soils, or that raised in the East may do best when sown in the West. Only study and personal experience on the part of each factory manager can determine what seed is best suited for the conditions in his region.

"For several years efforts have been made to raise seed on a commercial scale in various sections of the United States, particularly in the States of Michigan, Nebraska, Utah, Colo-

rado, and Washington, but not until recently has any serious attempt been made to raise it from pedigreed roots, or in accordance with the scientific methods found to give the best results.

### EXCELLENCE OF AMERICAN-GROWN SEED

"During the last three years the Department of Agriculture has been conducting extensive experiments in testing American-grown seed in comparison with the best grade of imported seed procurable. These experiments have shown a marked difference in sugar content, purity, and yield, and in these qualities the American-grown seed compared most favorably with the imported. This is remarkable, as the American-grown seed was grown by seedsmen who had little knowledge and made little use of the scientific methods practiced in Germany. If it is said that the superiority of American-grown seed in these trials was due to the fact that the imported European seed was of inferior grades, then it is high time we gave up depending upon Europe for our supply, as every effort was made to secure for these comparative tests the best grades of seed procurable in Europe, and the prices paid were as high as those paid by the most critical factories there. If it be said that the soil and natural conditions were responsible for the superiority of the American-grown seed, it makes more evident the desirability of growing our own seed and emphasizes the importance of our doing it according to strictly scientific methods."

As a result of the above and other warnings, American purchasers of sugar-beet seed have become more discriminating from year to year and gradually they

have weeded out the poorer brands of seed. This discrimination is reflected in the extraction of sugar per ton of beets, which has increased from 11.59 per cent. in 1903 to 14.21 per cent. in 1915, an increase of 2.62 per cent. or 22.6 per cent. more sugar extracted from each ton of beets sliced. The tons of beets per acre also have increased and, whereas the yield of sugar per acre was 1984 pounds in 1903, in 1915 it was 2870 pounds per acre, an increase of 44.6 per cent. These results are due in part to better seed, in part to better agricultural methods, and in part to better factory results.

## AMERICAN-GROWN SUGAR-BEET SEED

DEPARTMENT OF AGRICULTURE

*Sugar-beet Seed Experiment Station in Nebraska*

For a number of years sugar-beet seed has been grown to a limited extent in the United States, and most of the seed here produced has been superior to the best imported seed.

The earliest recorded attempt to produce sugar-beet seed in the United States was made by the United States Department of Agriculture at Schuyler, Nebraska, where the Department established a sugar-

beet seed Experiment Station in 1890. This station, the sorghum stations in Kansas and the cane-sugar station in Florida were established by the Department of Agriculture at the instance of Dr. Harvey W. Wiley, who was Chief Chemist of the Department from 1883 to 1912. Dr. Wiley's interest in the production of sugar began while he was studying at Berlin, and for thirty years he not only has been an enthusiastic champion of the idea of the home production of sugar, but his work and his writings have contributed more to the establishment of the present American beet-sugar industry than have those of any other scientist.

The Schuyler station, as well as all other sugar work of the Department, was under the direction of Dr. Wiley. The work at Schuyler was under the immediate supervision of Dr. Walter Maxwell, Dr. Wiley's assistant.

The station was not supplied with highly-developed, carefully-grown, expensive "élite" seed, such as is universally used in Europe for breeding sugar-beet seed. The best with which it had to operate was ordinary European commercial seed such as is used for growing factory beets.

In 1891 and 1892 small quantities of seed were

produced and in order to determine its relative quality; it was planted in plots at the station, alongside of other plots which were planted with the best foreign seed, of the same and other brands. The soil and the care given the different plots were identical.

It was found that the climatic conditions at Schuyler were not favorable for the production of sugar-beet seed, but notwithstanding this, the lack of high-grade seed from which to breed and the lack of experience in sugar-beet seed production, the beets produced from the home-grown seed out-ranked in every respect those produced from the best foreign seed.

The results obtained are recorded in Bulletins No. 39 and 52 of the U. S. Department of Agriculture, which were prepared and written at that time. The following comment by Dr. Wiley concerning the results obtained at the Schuyler station are from the Department of Agriculture Farmer's Bulletin No. 52, 1897:

"In the experiments conducted at the station at Schuyler during the season of 1893 a comparison of the beets grown from domestic and imported seeds was made. The plants from the native-grown seed seemed to have a higher vitality and to be better suited to the climatic conditions of the locality than those grown from imported seeds. They showed during the growing season a more abundant foliage and a better develop-

ment of roots. The higher vitality and quality of the beets grown from domestic seed illustrate in a forcible degree the advisability of the production of our beet-seed at home. Even granting that seeds produced in foreign countries have the same high qualities, it must be admitted that their vitality is in danger of being very much diminished during shipment to this country. The moist air of the holds of the ships in which they are transported often produces moldiness and incipient germination, which tend to greatly diminish their value. Not only did the beets produced from the home-grown seed have a higher percentage of sugar, but they also afforded a higher yield per acre, as determined in the experiments at Schuyler. The mean tonnage per acre from the home-grown seed was 21.1 and from the imported seed, 17.9 The mean pounds of sugar produced per acre from the home-grown seed was 5891 and from the imported seed 5185. This shows an increase of about 12 per cent. in the actual quantity of sugar per acre when domestic seed was used. These data should be carefullly studied by all those who are interested in the production of beet sugar in this country. Perhaps the time has not yet come for the inception of such a work, but it is evident that it will not be long before there will be a demand for the establishment in this country of a plantation or plantations devoted exclusively to the production of beet seeds on the most approved scientific principles.

"The quantity of seed required to plant an acre is about 15 pounds. The approximate number of acres planted to beets in this country during the past season was 30,000, requiring 450,000 pounds of seed. It is evident that there is already an opportunity for the active operation of a large plantation

devoted exclusively to the production of beet seeds for domestic use.

"Another point to be considered is that by the importation of foreign seeds there is danger of introducing those fungoid and microbian diseases of beets which have produced such ravages in Europe."

Such high results did this seed yield that the Oxnard Beet Sugar Company paid the Government 20 cents per pound for all it would sell, or 50 per cent. more than that company then paid for the best foreign seed.

With such flattering results, obtained under adverse circumstances 25 years ago, it is fair to presume that had this work been continued, the United States now would be producing sugar-beet seed which would yield beets materially superior to any now produced in the world.

In the political upheaval of 1892 Mr. Cleveland became President, and when Sterling Morton assumed the portfolio of Secretary of Agriculture he ordered all Government experimental sugar work abandoned. The Schuyler, Nebraska, and Sterling, Kansas, sugar-beet stations closed their doors. The writer is informed that the Medicine Lodge, Kansas, sorghum plant, which had cost $20,000 to build, had a capacity

of 20 tons per day and was extracting 230 pounds of sugar per ton of sorghum, was sold for $1800. The Runnymede, Florida, cane-sugar mill, which had cost $18,000 to erect and was about to have steam turned on for the first time, was sold for $2000. The beets which had been planted in the newly-established California station rotted in the ground.

With the abandonment of this work and the abolition of the sugar bounty, the Government turned its back on all that pertained to the development of a home sugar industry.

## STATE OF WASHINGTON SUGAR-BEET SEED FARM

With the return of the Republicans to power in 1896 and the appointment of James Wilson as Secretary of Agriculture, the Government renewed its beet-seed and other sugar investigation work, paying especial attention to seed developments in Utah, Michigan and New York, at all of which places good results were obtained.

The number of beet-sugar factories rapidly increased and with the erection of a factory at Waverly, Washington, Mr. E. H. Morrison, who owned an

800-acre farm in that vicinity, began growing several hundred acres of beets for the factory.

Morrison had been growing vegetable seed for a number of years and in 1899 he siloed some mother beets of several different varieties. In 1900 he produced a few hundred pounds of beet seed. The results obtained from the various brands of seed experimented with, indicated that the Klein Wanzleben Original would bring the best results, and on this variety Morrison concentrated his work. As with the Government experiments in Nebraska ten years before, Morrison had no high-priced, pedigreed élite seed to breed from, but began his work with ordinary commercial seed.

In order to encourage the enterprise, the Department of Agriculture purchased, tested, and distributed considerable quantities of the Morrison seed. The results secured were flattering. Morrison increased his plantings and in 1903 produced 35 tons of seed, and siloed a million "mothers" to be planted the following spring.

To determine the relative germinating value of foreign and domestic seed, the Department of Agriculture tested 9 brands of foreign and 4 brands of domestic seed. Among the foreign seed tested was

Dippe, Vilmorin, Rabbethge & Giesecke, Schreiber, and Breustedt. The tests of domestic seed were Morrison, grown in the State of Washington; Utah Sugar Company, grown in Utah; Agnew, grown in California, and Alma Sugar Company, grown in Michigan.

Some of the domestic seeds tested fell below some of the foreign brands, but the Washington seed showed a materially higher germinating power than did the best foreign seed. The average results secured from the 9 brands of foreign seed and from the Washington seed were as follows:

| | Nine Brands Foreign Seed. | Washington Seed. | Superiority of Washington Seed. |
|---|---|---|---|
| | | | Per Cent. |
| Number of sprouts in 6 days | 150.4 | 198.5 | 31.9 |
| Number of sprouts in 14 days | 166.7 | 203.0 | 21.8 |
| Average per cent. of balls developing sprouts in 6 days | 70.3 | 96.5 | 37.3 |
| Average per cent. of balls developing sprouts in 14 days | 76.2 | 97.5 | 28.0 |
| Total average number of sprouts from $2\frac{1}{2}$ lb. seed, in 6 days | 70,973 | 96,800 | 36.4 |
| Total average number of sprouts from $2\frac{1}{2}$ lb. seed, in 14 days | 78,175 | 98,600 | 26.1 |

The sugar content of the Washington beets, as shown by 185 tests made by the State Agricultural College at Pullman, Washington, October 10, 1903, was as follows:

| | | |
|---|---|---|
| Below 18% | 8 beets, average sugar in beet | 17.26% |
| 18–19 | 15 | 18.48 |
| 19–20 | 52 | 19.38 |
| 20–21 | 53 | 20.30 |
| 21–22 | 39 | 21.22 |
| 22–23 | 16 | 22.22 |
| 23–24 | 1 | 23.00 |
| 24– | 1 | 24.00 |
| Total | 185 | 20.21% |

162 Beets average.....21.69%
110 Beets average.....22.15%

The Department of Agriculture purchased 5 tons of the Washington seed at 10 cents per pound, but Morrison was unable to induce the sugar factories to purchase any portion of the balance at that price.

Morrison appealed to Secretary of Agriculture Wilson, declaring he could not afford to sell his seed at less than 10 cents per pound and that he would let his mother beets rot in the silo, rather than continue the work if he could not find a market for his product.

In appealing to the writer to interest himself in the placing of the Washington seed, Secretary of Agriculture Wilson wrote, in part, as follows, on February 17, 1904:

"The report of the scientist which I have had on the sugar-beet seed farms of Europe for five months and the experiments which have been made in this country in producing sugar-beet seed show the imperative necessity of producing our seed in this country at the earliest practicable moment. In the mean time the greatest care should be exercised in the selection of foreign-grown seed in order that a much larger proportion of our sowings will be of the best quality such as is used exclusively by European beet growers.

"The seed question is the very heart of the industry, the foundation upon which depends success or failure, for without good seed no combination of propitious conditions can bring success either to the farmer or the manufacturer.

"We have been co-operating to some extent with Mr. Morrison of the State of Washington, who has a seed farm several hundred acres in extent. Our experiments show that with equal attention to the scientific details we can produce at home a seed far superior to the best European seed. Last year this Department purchased a quantity of the Washington seed, this seed being produced from mothers selected from factory beets which averaged 19 per cent. sugar, the original seeds being also home-grown. This seed was distributed among sugar-beet farmers and wherever we have been able to secure comparative tests it has given excellent results, its great vitality being specially marked. This year we shall send out several tons of the 1903 crop.

"I have asked Congress for a special appropriation for conducting scientific sugar-beet seed work and in case Mr. Morrison continues his efforts, have arranged that the seed scientists of this Department take entire charge of the scientific work on his

farm. By utilizing the science of two continents to develop a definite, fixed strain of highly bred American beets, I am convinced that they will be higher in germinating power, vitality and tonnage and several per cent. higher in sugar content and purity than the best beets grown from foreign seed. By centralizing our efforts for the present in one favorable locality we will accomplish results most quickly, when other seed growers can take up the work and perpetuate the strain, raising any quantity desired.

"* * * In sugar-beet seed the market is confined to the fifty or more factories which your association represents and without their co-operation in furnishing a market for the seed produced, the present plans cannot be carried out.

"* * * The higher germinating power and extreme vitality of sprouts and beets from American-grown seed will insure an earlier stand, a more vigorous growth and hence a higher tonnage. This also promotes immunity from diseases and resistance to damage by insects and drouth. Furthermore, 25 per cent. less seed can be used and still secure a better stand than with imported seed. Another feature is that where good and poor seed is not thoroughly mixed, it sometimes occurs that a considerable part of or the whole of a row does not germinate, thus resulting in severe loss to the farmer. With American-grown seed this risk would be entirely eliminated.

"You can perform no more valuable service to the members of your association than in calling their attention to the true condition of the sugar-beet seed business and pointing out the remedy for it."

As the result of much writing and the issuance of

40 pages of mimeographed matter, the writer finally succeeded in placing the 30 tons of seed among factories located in Nebraska, Minnesota, Colorado, Wisconsin, Michigan, Ohio and New York, at 8.8 cents per pound, and the seed was planted in the spring of 1904. So superior were the results obtained that from that time on, Morrison increased his acreage and had no trouble in disposing of all the seed he raised.

The Department of Agriculture established a station on the Morrison farm in 1905 and took entire charge of the scientific work, which was carried on under the direct charge of Mr. Reed, under the direction of Mr. J. E. W. Tracey, Assistant Superintendent of Testing Gardens, Department of Agriculture. Again it appeared that the sugar factories of the United States soon would be supplied with higher grade seed than any other factories in the world.

But the fruit boom struck eastern Washington in 1911, the boomers offered Morrison more for his land than it was worth for growing seed, he sold his farm and the Government abandoned its station. As had been the case with the Nebraska experiments of ten years before, the benefits of the advance which had been made were lost.

That the Washington seed was constant and continued to yield superior results is shown by the Government records for six years, as embodied in the following tables from "Progress of the Beet Sugar Industry in the United States" in 1909, issued by the Department of Agriculture:

TABLE I.—RELATIVE PERFORMANCE OF SUGAR-BEET VARIETIES FOR THE ENTIRE SIX-YEAR PERIOD COVERED BY THE TESTS

| Designation of Variety Tested. | Arranged by Stations. | | | | Arranged by Years. | | | |
|---|---|---|---|---|---|---|---|---|
| | Roots Tons per acre. | Sugar. | | Standing of Variety Tested. | Roots Tons per acre. | Sugar. | | Standing of Variety Tested. |
| | | Per Cent. | Lbs. per acre. | | | Per Cent. | Lbs. per acre. | |
| Morrison | 15.26 | 16.69 | 5,011 | 1 | 13.40 | 16.53 | 4,325 | 1 |
| Original | 14.14 | 17.43 | 4,847 | 2 | 12.49 | 17.14 | 4,206 | 2 |
| Breustedt | 14.20 | 16.64 | 4,664 | 4 | 12.69 | 16.36 | 4,078 | 3 |
| Mette | 14.38 | 16.48 | 4,675 | 3 | 12.56 | 16.31 | 4,007 | 6 |
| Schreiber | 13.95 | 16.95 | 4,632 | 6 | 12.17 | 17.03 | 4,041 | 4 |
| Braune | 14.40 | 16.34 | 4,635 | 5 | 12.74 | 16.15 | 4,031 | 5 |
| Heine | 13.87 | 16.89 | 4,608 | 7 | 11.98 | 16.70 | 3,894 | 9 |
| Utah | 13.88 | 16.78 | 4,597 | 8 | 12.09 | 16.70 | 3,962 | 7 |
| Hoerning | 14.37 | 16.25 | 4,547 | 9 | 12.51 | 16.15 | 3,911 | 8 |
| Jaensch | 13.79 | 16.55 | 4,506 | 10 | 11.93 | 16.44 | 3,839 | 11 |
| Dippe | 13.43 | 16.85 | 4,452 | 11 | 11.86 | 16.67 | 3,864 | 10 |
| Kuhn | 12.88 | 17.12 | 4,333 | 12 | 11.54 | 16.87 | 3,821 | 12 |

TABLE XI.—RELATIVE STANDING, BY STATIONS AND BY YEARS, OF SUGAR-BEET VARIETIES TESTED FOR ALL YEARS

| | Arranged by Stations. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Colorado, Ft. Collins 3 Years. | Michigan, East Lansing 5 Years. | Michigan, Holland 6 Years. | New York, Geneva 6 Years. | Oregon, Union 3 Years. | Utah, Logan 4 Years. | Washington, Fairfield 6 Years. | All Stations. |
| Morrison | 1 | 4 | 3 | 1 | 1 | 2 | 1 | 1 |
| Original | 5 | 2 | 5 | 3 | 2 | 1 | 2 | 2 |
| Breustedt | 9 | 5 | 7 | 2 | 9 | 3 | 8 | 4 |
| Mette | 2 | 11 | 10 | 9 | 5* | 7 | 5 | 3 |
| Schreiber | 8 | 1 | 4 | 4 | 10 | 12 | 3 | 6 |
| Braune | 6 | 6 | 9 | 5 | 4 | 5 | 12 | 5 |
| Heine | 7 | 3 | 11 | 10 | 8 | 4 | 11 | 7 |
| Utah | 4 | 9 | 12 | 7 | 5* | 6 | 4 | 8 |
| Hoerning | 3 | 12 | 1 | 12 | 11 | 9 | 6 | 9 |
| Jaensch | 10 | 10 | 2 | 8 | 3 | 10 | 7 | 10 |
| Dippe | 11 | 8 | 8 | 6 | 7 | 11 | 9 | 11 |
| Kuhn | 12 | 7 | 6 | 11 | 12 | 8 | 10 | 12 |

| Designation of Variety Tested. | Arranged by Years. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | All Yrs. |
| Morrison | 1 | 7 | 1 | 1 | 2 | 6 | 1 |
| Original | 3 | 3 | 2 | 4 | 1 | 3 | 2 |
| Breustedt | 9 | 2 | 5 | 2 | 6 | 8 | 3 |
| Mette | 10 | 12 | 4 | 6 | 4 | 5 | 6 |
| Schreiber | 2 | 6 | 6 | 12 | 3 | 2 | 4 |
| Braune | 4 | 4 | 9 | 3 | 7 | 7 | 5 |
| Heine | 6 | 5 | 7 | 11 | 9 | 9 | 9 |
| Utah | 7 | 9 | 10 | 5 | 8 | 4 | 7 |
| Hoerning | 11 | 10 | 3 | 7 | 10 | 12 | 8 |
| Jaensch | 12 | 13 | 8 | 8 | 11 | 1 | 11 |
| Dippe | 5 | 1 | 11 | 10 | 12 | 10 | 10 |
| Kuhn | 8 | 11 | 12 | 9 | 5 | 11 | 12 |

* The Mette and the Utah varieties have the same relative standing at Union, Oregon.

## SEED GROWING IN CALIFORNIA

Some years ago J. B. Agnew & Company, of Agnew, California, near San Francisco, produced commercial seed for several seasons, but the enterprise did not meet with success and was abandoned. C. C. Morse & Company also gave the work a thorough test, but were unable to produce seed successfully. At Oxnard, in southern California, the American Beet Sugar Company conducted extensive experiments in seed growing for a number of years, but finally gave up the effort.

The main trouble in California is that such a large percentage of the mother beet seed is liable to go to seed the first year. While some years but 5 per cent. of the seed would develop seed stalks the first season, other years, under identical cultural conditions, 80 per cent. would develop seed stalks the first year. This inconsistency is attributed to the average uniform temperature, which does not insure a complete check of the selected mother beets during the winter.

To overcome this difficulty, specially constructed siloes for the mothers were prepared and the mothers were planted at various dates, but the effort did not

succeed. Nevertheless, experiments still are being conducted in that state, both by sugar companies and by the U. S. Department of Agriculture.

## SEED GROWING IN UTAH AND IDAHO

In 1899 the Utah Sugar Company began experimenting with sugar-beet seed culture at Lehi, and since has planted from 5 to 20 acres to mother beets yearly. Since 1907 this company also has grown from 10 to 30 acres yearly at Sugar City, Idaho. Originally, the work was conducted by Mr. C. A. Granger, subsequently under Mr. Mark Austin, Agricultural Superintendent of the company. The quality of the seed was excellent; the main difficulty experienced was in keeping the mother beets through the winter. Large sums of money were expended in trying to make the enterprise a success, but it was not until 1912, when Mr. W. K. Winterhalter, who represented the Russian sugar-beet seed firm of Buszczynski & Lazynski, became associated with the enterprise, that the work assumed commercial proportions, since which time the production has been greatly increased, now amounting to 10,000 to 15,000 bags annually.

In both sugar content and germination, the results secured from this seed are equal to those obtained from the best imported seed.

## SUGAR BEET SEED EXPERIMENTS IN SOUTH DAKOTA

The Agricultural Experiment Station of South Dakota, in which state no beet-sugar factory has as yet been erected, has been experimenting with sugar beet culture since 1888 and with the development of American strains of sugar beet seed, since 1891. In a bulletin,* which reviews the work of the station since 1888, it is stated that they found no pure strains of commercial seed that would give uniform tonnage or percentages of sugar, but that on the contrary, beets grown from the best varieties of seed gave beets which "*differed from one another by 10 per cent sugar in the beet.*" There was also a great difference in the purity of the beet and in the tonnage yield per acre.

By making selections the average sugar content of

* Sugar Beet Culture in South Dakota. Results to Date, Bulletin No. 142, by James H. Shepard, Chemist, Department of Chemistry, Agricultural Experiment Station, South Dakota State College of Agriculture and Mechanic Arts, Brookings, S. D., January, 1913.

the beet was raised 3 per cent in the first generation produced from Dakota seed, and in later selections, while all beets were rejected which did not analyze higher in sugar than did the highest at the beginning of the experiments, and higher than the average of all the commercial beets grown in the United States, the rejections amounted to but 3.4 per cent of the beets tested. No rows of beets in which every beet was tested averaged less than 20 per cent sugar, the highest average for any row was 21.5 per cent and the highest individual beet tested, contained 25.4 per cent sugar.

It is obvious that if by selection, the poorer quality of seed which we are using be eliminated, and from the superior types of foreign elite seed, strains of high tonnage, high sugar content and high purity beets be bred, the reduction in the farmers cost of producing beets and the factory cost of producing sugar would be materially reduced. In fact, even with our high wage rates, it might so revolutionize costs as to make this the cheapest beet-sugar producing country in the world.

The following from South Dakota, Bulletin No. 142, indicates the results which may be attained by beginning at the foundation and breeding pure American strains of sugar beet seed:

"This year (1891) also saw the beginning of raising sugar beet seed from analyzed mother beets. A small quantity of seed from several varieties was grown. When planted the next year the beets grown gave a promising increase over the mothers planted for seed. In some instances 3 per cent more sugar was found. Thus by selection a 15 per cent beet was raised to 18 per cent. This is mentioned here, since this small beginning has borne fruit in the splendid achievements of the present time. . . .

"The object of the new work was to breed up strains of sugar beets in which the individuals should give uniformly high sugar percentages, while the beets should be large enough to make a profitable tonnage for the farmer.

"The first year of this work in co-operation with the Bureau of Plant Industry (U. S. Department of Agriculture), Dr. Townsend secured 26 different varieties of sugar beet and stock beet seeds. The sugar beet seed was from the best American and foreign growers who were furnishing our factories with commercial seed.

"Each variety was planted and when ripe the variety was harvested and the beets, after a thorough sorting for shape, type and size, were siloed in a cool cellar. Later they were all brought to the laboratory and each beet was analyzed separately. Any sugar beet that failed to have 15 per cent sugar in the beet this year was rejected. This severe culling process left good beets of proper form and size with at least a good commercial per cent of sugar. Some varieties were thrown out entirely. And of the beets saved in the field in some varieties the number of rejected beets were small, in others it amounted to as much as 20 per cent.

"We were unable at this time to cull closer than this. But some varieties gave one or two beets out of the whole number analyzed that went up to 20 per cent sugar in the beet, and one gave 24.8 per cent sugar. These few best ones were planted separately and sacked so they self-fertilized, thus giving us the beginnings of new strains.

"But one thing became immediately apparent, and that was *that there were no pure strains of sugar beet seed in the country that would give uniform percentages* among the individuals of any variety. In even the best varieties individuals were found that differed from one another *by 10 per cent sugar in the beet.* The enormous waste that would ensue from using such seed may be readily imagined. The poor beets cost just as much to grow as the good ones and they reduced the profits of both farmer and manufacturer. . . .

"In 1908, 21 more varieties of seed were secured and treated as the first 26. . . . The number rejected on a 15 per cent basis ranged all the way from 50 per cent to 100 per cent. In 1909 we were busy propagating and testing out not only the main lots of beets and seed grown during the past two years, but owing to an early freeze in October we were able to give the first 26 varieties grown as severe a culling as we had given the seeds planted the previous year. . . . The culling was most severe, the rejects often constituted over half the beets analyzed. But this has proven a blessing in disguise. But we commenced to see for the first time that we had made substantial gains in reducing the variation between individuals of the same strain. The variation of 10 per cent had been reduced in most cases to 5 per cent or 6 per cent. In only a very few cases did it rise to 8 per cent, while in some cases it had dropped to 3 per cent or 4 per cent. The mother beets averaged about 15 per cent sugar in the beet.

"In 1910 we continued the work, analyzing, selecting, and testing out the new strains of mothers and seed we had grown. . . . Upwards of 4000 beets were analyzed and classified. Up to this time that work has borne no fruit. But when we came to select our mother beets after analysis we made the satisfactory discovery that the individual variation between beets of the same variety was rapidly disappearing. On the basis of 15 per cent the rejects had dwindled down to an average of only 3.4 per cent for

all varieties. The lowest per cent rejected on account of low sugar content was 0.9 per cent, and the highest was 7.0 per cent. When we consider that when these same strains at their last selection required the rejection of around 50 per cent and over, it needs no erudition to discover the remarkable progress made. Also we made the largest number of individual analyses this year that has been made in this work. This year the mother beets averaged over 17 per cent sugar in the beet. This fact marked another distinct advance in our quest for a high and uniform percentage of sugar.

"For 1911, owing to the fact that we now had some very good strains well on their way toward our ideals, other phases of the work are undertaken. . . . In analyzing beets for mothers we were able to reject all under 18 per cent sugar in the beet this year. Here is a mighty advance. With this high standard the reject per cent was low, running around 10 per cent or under. In no variety did the per cent sugar in the beet as determined by a composite analysis in which every beet in the row was analyzed fall below 20 per cent. The highest average was 21.5 per cent; even the rejects averaged well over 15 per cent.

"We have been looking all these years for a sugar beet that will give 25 per cent sugar in the beet. And this year we not only found several that were that high but we surely caught a big one, 25.4 per cent. Perhaps they grow richer. We do not know.

"As for tonnage, the different varieties gave from 20 to 24 tons per acre. Owing to the great interest at this time there is appended a table giving a summary of the results secured along commercial lines during 1911 and 1912. The table is self-explanatory. The pounds of sugar per acre were calculated by weighing the topped beets. Then this weight was multiplied by the per cent sugar in the beet. In factory practice around 4 per cent of the sugar in the beet is not recovered as sugar. Some of it goes

to molasses. The molasses is worked up into alcohol and other valuable products.

TABLE 1

VARIETY TESTS OF SUGAR BEETS FOR 1911

| Variety No. | No. Rows Analyzed. | No. Beets Analyzed. | Wt. Beets Analyzed lbs. | Degree Brix. | Per Cent Sugar in Juice. | Purity. | Per Cent Sugar in Beet. | Pounds Beets per Acre. | Pounds Sugar per Acre. |
|---|---|---|---|---|---|---|---|---|---|
| 35 | 5 | 248 | 267 | 19.6 | 17.1 | 88 | 16.3 | 31,015 | 4,550 |
| 40 | 7 | 368 | 354 | 19.6 | 17.0 | 87 | 16.2 | 26,515 | 3,865 |
| 42 | 6 | 288 | 297 | 19.8 | 17.6 | 89 | 16.7 | 32,016 | 4,812 |
| 43 | 6 | 326 | 307 | 20.4 | 17.9 | 89 | 17.0 | 32,894 | 5,031 |
| 44 | 6 | 317 | 303 | 20.3 | 17.9 | 88 | 17.0 | 32,665 | 4,797 |

VARIETY TESTS FOR 1912

| | Width of Row. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 35 | 18 | 142 | 115 | 24.0 | 21.0 | 88 | 20.0 | 46,379 | 8,532 |
| 42 | 18 | 158 | 112 | 24.4 | 22.0 | 90 | 20.9 | 45,173 | 8,497 |
| 43 | 18 | 146 | 118 | 24.5 | 22.0 | 88 | 20.9 | 47,593 | 8,962 |
| 44 | 18 | 138 | 101 | 25.4 | 22.6 | 89 | 21.5 | 40,737 | 7,782 |
| 18S | 18 | 120 | 106 | 25.6 | 23.2 | 91 | 22.0 | 42,753 | 8,653 |
| 21S | 18 | 132 | 106 | 24.6 | 22.0 | 89 | 20.9 | 42,753 | 8,025 |
| SD1 | 18 | 143 | 111 | 24.2 | 21.4 | 88 | 20.3 | 44,766 | 8,268 |

"Our rejects from the mother beet analyses will give a higher per cent than the average of all the commercial beets grown in

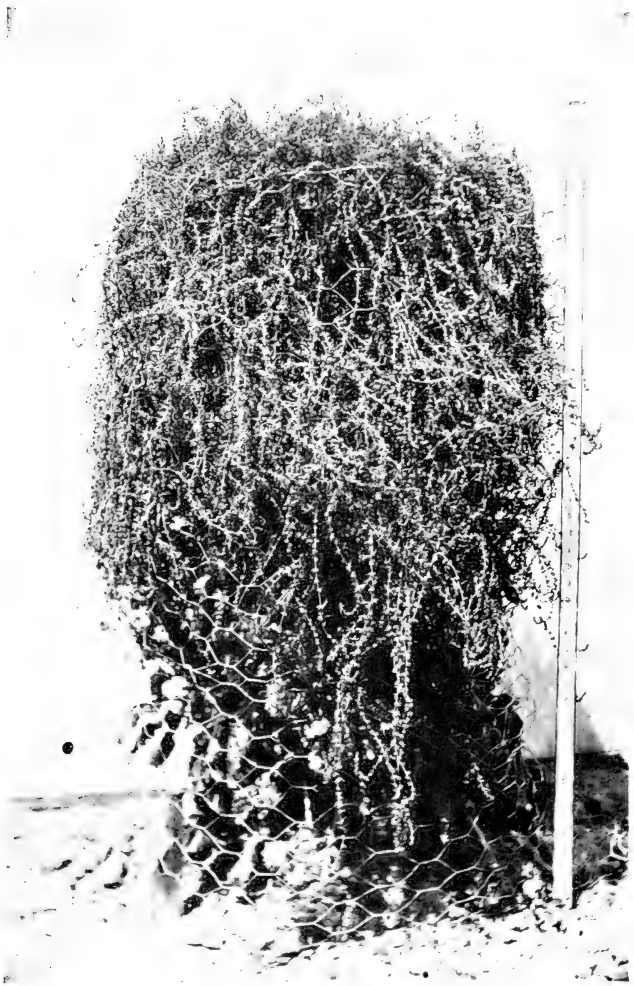
this country. California has the highest per cent sugar in the beet of any state where they are grown commercially, 18.54 per cent while her tonnage is 10.72."

## SINGLE-GERM BEET BALLS

In forming beet seed nature seems to have been perverse, in that while she compels us to plant several seeds in a place and thus starts the beetlets in cluster, they cannot be grown to advantage in clusters. We plant four kernels of corn in a hill, but the beet requires that its nearest neighbor shall be 8 inches removed. The several peas which grow in a pod easily are separated and can be planted singly, but the several beet-seed germs which grow in a beet-ball cannot be separated.

The ball in which beet seed is incased is a hard, woody, fibrous substance and was placed there by nature for the purpose of allowing moisture, etc., to enter by osmosis in proper proportions so as to regulate the germination of the plant.

These balls contain from 1 to 7 distinct seeds or germs, with an average germination of $3\frac{1}{2}$ plants per ball. The consequence is that in order to leave but one plant every eight inches in the row, when



DEVELOPING SINGLE-GERM BEET SEED

Plant that has been covered with muslin bags upon a frame of wire netting. Many of the racemes have grown through the meshes of the netting.

the plants appear above the ground and show their third leaf, all superfluous plants must be pulled up, care being exercised that the remaining plants be injured as little as possible. At best, the shock is so severe that the remaining plants wither and lie flat on the ground for several hours after being thinned. In addition to the injury to the plants, thinning is a slow, expensive, back-aching task which must be done by hand.

Several years ago it was proposed to plant the beet-balls in paper tubes in a seed-bed, thin them while the tubes still were on trays, convey the trays to the field and plant the tubes, much as tobacco plants are planted. Because of the attendant expense, this method never passed the experimental stage.

Then a machine was invented which twisted up beet-balls, one in a place, at given distances within a continuous narrow roll of paper, which could be unwound from a field implement which made a trench, laid the paper roll and covered it with earth as the machine was drawn across the field. But the inventor overlooked the fact that each beet-ball contained several germs, hence his proposed method did not obviate the necessity of thinning on hands and knees.

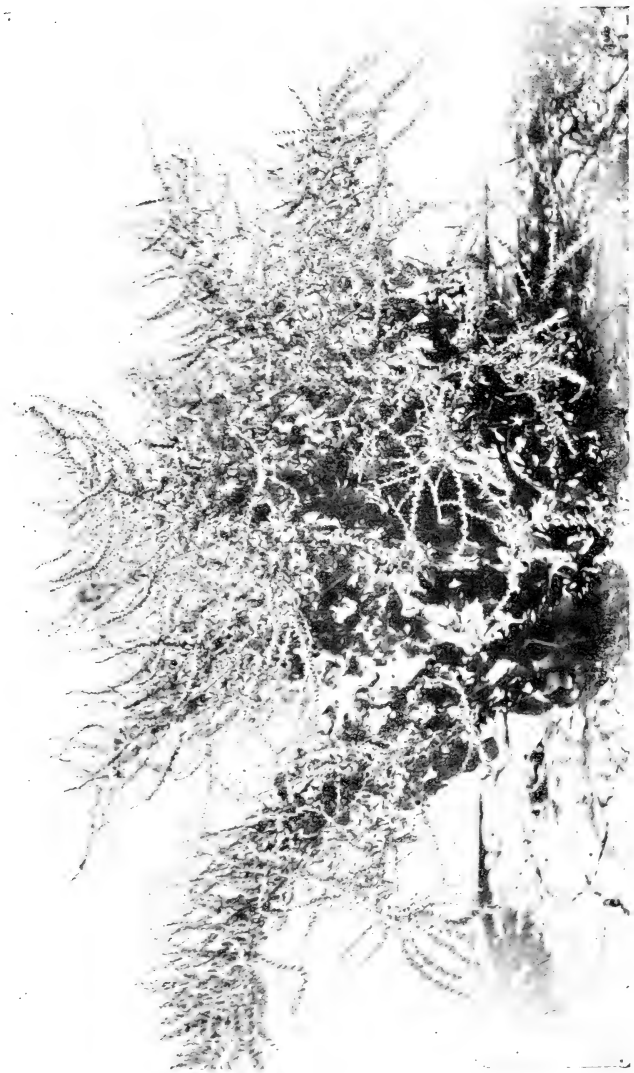
About the same time, a German seed grower tried

TYPE OF SEED BEET READY TO HARVEST

to obviate the necessity of thinning, by passing the seed-balls through a grater and cracking them into several parts. Some of this cracked seed was placed on the American market, but did not give satisfactory results. The drawbacks to this method were both numerous and serious. Some of the seed germs were destroyed in the cracking machine. Others were exposed and the function of the beet-ball to regulate the germination was destroyed. The oxalates in the beet-ball did not perform their function of protecting the young plant from its micro-enemies. And finally, unless a large portion of the germs were ruined, it was impossible so to crack the balls but that many of the pieces contained more than one germ and the field had to be thinned as usual.

With these experiments in mind, the writer cracked open and examined thousands of beet-seed balls and finally concluded that the only manner in which the desired result might be attained would be to breed a single-germ beet-ball. If the botanists could change the whole nature of the beet's seeding habit and induce it to become a biennial instead of an annual, why could they not change its habit of growing more than one seed in a ball.

The value of such a seed scarcely could be measured



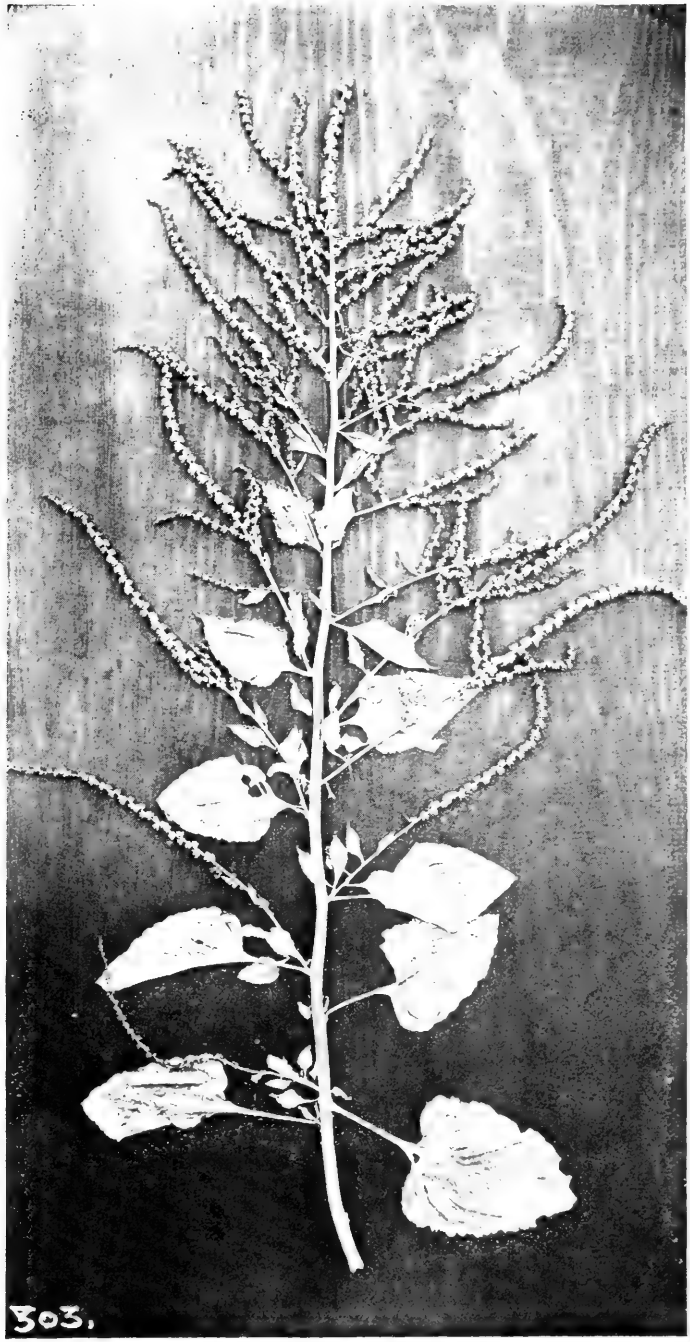
TYPE OF SEED BEET READY TO HARVEST

in dollars. Not only was the thinning expensive, but careful German experiments had shown that unless beets were thinned at exactly the right time, the loss in tonnage, due to the injury to the remaining beetlet by reason of pulling up the superfluous plants, was very great. One German experiment conducted on four plots of ground where all conditions of seed, soil and care, except the time of thinning, were the same, had given the following results:

| | | | | | | |
|---|---|---|---|---|---|---|
| Plot No. 1, | thinned | at the right time, | yielded | 15 | tons | of beets. |
| 2, | " | one week later, | | $13\frac{1}{2}$ | " | " " |
| 3, | " | still one week later | | 10 | " | " " |
| 4, | " | still another week later | | 7 | " | " " |

Now if the very womb of the seed germ could be so changed as to contain but one germ instead of several, a single seed could be planted in a place, the cost of the hand work of thinning could be saved and the tonnage would be increased from 25 to 40 per cent., for beets rarely, if ever, are thinned at just the right moment. Even when they are, the shock caused by removing the intertwined roots is severe. With but one beetlet growing in a place, they would be entirely free from shock.

To insure a good stand, the beet-balls could be




BEET-SEED STEM

Mounted on board 21×42 inches.

dropped in the rows, one inch or two inches apart and the superfluous plants could be removed with a hoe at the farmers' leisure, without injury to the remaining plants. To insure sufficient power to break through a crusted surface in sections where showers were likely and the soil was caked, oats could be drilled in with the beet seed, or the crust could be broken with the proper agricultural implements.

Inasmuch as the average yield in the United States is but 10 tons per acre, while a perfect stand of 2-pound beets planted in rows 18 inches apart and thinned to 8 inches, would yield 43 tons per acre, the chance for materially increasing the tonnage is very great.

The suggestion met with no encouragement from sugar men; they did not believe it possible to breed a single-germ beet-ball. But the moment the writer broached the subject to Secretary of Agriculture Wilson, he became enthusiastic over it, declaring that it not only was possible, but probable, and within twenty-four hours, a bevy of Department clerks was at work sorting out single-germ beet-balls from commercial seed.

The only mark on beet-balls which indicates the presence of seed is an almost imperceptible flattening directly over each seed pocket. The entire surface

DEVELOPING SINGLE-GERM BEET SEED
Two extremely diverse terminals of seed stems.

of each little beet-ball had to be examined minutely. From between 400,000 and 500,000 beet-balls 4000 singles were secured, the exact proportion of singles being 0.98 of one per cent. of the balls examined.

The writer had reasoned that because of the fact that the ball which enclosed a single was more than one-half the size of that enclosing a double, and that of a double was more than two-thirds the size of a three-germ ball, the less the number of seeds a ball contained, the larger would be their breakfast. His boyhood recollection was that the sow that raised the smallest litter, raised the biggest pigs, but he was told that his reasoning could not be applied to sugar-beet seed and that vitality would have to be bred into the plants after the single germ characteristic should have become fixed.

This was in the early spring of 1903, and in due course the singles were planted on the Arlington Experimental Farm of the Department of Agriculture, near Washington. The germination was favorable, and contrary to the predictions of the botanists, the vitality of the plants was abnormally high, the highest of any sugar-beet seed ever grown by the Department. At the close of the season about 1000 beets grown from

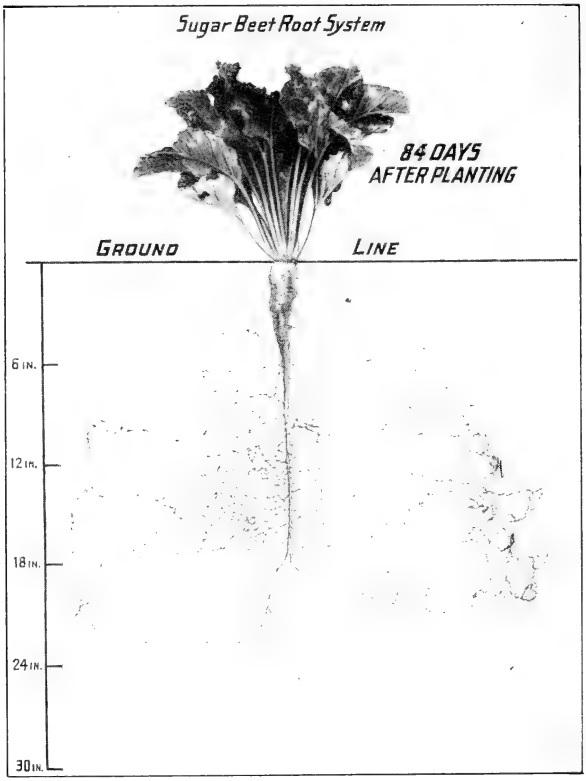
the single-germ seed were selected and siloed for the next season's planting.

In the spring of 1904 the single-germ "mothers" were shipped by express and by post, to Lehi, Utah.

DEVELOPING SINGLE-GERM SUGAR-BEET SEED

Flower stalks possessing only single flowers, covered with paper bags to prevent cross pollination

Drs. C. O. Townsend and E. C. Rittue, Pathologist and Assistant Pathologist, Department of Agriculture, had been placed in direct charge of the work and upon arrival of the mothers they were planted 3×3 feet.




ROOT SYSTEM OF COMMERCIAL SUGAR BEETS

It is estimated that one ton of fibrous roots per acre remains in the ground after the main root has been harvested.

Only two of the plants set out failed to live and less than 1 per cent. failed to produce seed stalks.

Fifty of the plants which possessed the highest number of single flowers were selected for pollination purposes. In the work of poliination, single flowers were covered with paper bags in order to protect them from the pollen of other beet-flowers, a ndthe branches which bore multiple flowers were removed. While opening the flowers with a needle or scalpel in order to cross-fertilize them, a tent was erected to surround both plant and operator and protect the flowers at such times against stray pollen that might be floating in the air.

After the flowers were treated and covered with paper bags, the entire plant was covered with a cloth bag in order that the paper bags might not be blown off. Each plant was carefully examined from time to time to remove the superfluous growth that was forced from the nodes as a result of the excessive trimming due to removing the branches which bore multiple flowers. As soon as the seed had set, the paper bags were removed, but the cloth bags remained over the plants until the seed ripened.

The seed ripened in August and that from each of the pollinated plants, and the other plants which showed the greatest number of singles, was gathered

TWO OF THE MANY WIDELY VARYING TYPES OF SUGAR BEETS FOUND IN COMMERCIAL FIELDS. IDEAL WEIGHT FOR FACTORY PURPOSES, ABOUT TWO POUNDS

A perfect stand of 2-pound beets planted in rows 18 inches apart and thinned to 8 inches in the row, would yield 43 tons per acre. Average acreage yield in the United States 10.4 tons, in Germany 14.17 tons.

separately. Owing to the method of pollination, it was impossible to determine what proportion of the seed-balls of the pollinated plants were single. Of the other plants, the highest, or number 51, yielded 25 per cent. single-germ balls and the next 10 averaged 17 per cent. singles.

In 1905 the best plant yielded slightly over 50 per cent. singles, two plants yielded between 49 and 50 per cent., several exceeded 40 per cent. and many exceeded 30 per cent.

The third generation yielded about the same as the second. In the fourth generation some of the plants yielded 60 to 70 per cent. singles, two produced as high as 80 per cent. and one produced 85 per cent. singles. The very high plants proved to be weaklings and eventually died without producing further results.

The work was interrupted during 1913 and 1914, but fortunately, samples of nearly all the seed which had shown promising results in 1912 have been saved. The best plants with which the Department now is working yielded 60 to 70 per cent. singles.

In addition to the production of single-germ plants, the Department is conducting with this experiment a number of investigations in regard to weight and quality of seed, as well as in regard to the quality

of roots produced from singles as compared with those produced from multiple germ seeds.

No doubt is expressed but that the single germ characteristic will become fixed, but as to how soon and as to how much of a tendency there will be to revert, only can be determined by further investigations and the lapse of time.

NOTE. For further details of this work, see "Single-Germ Beet-Balls and Other Suggestions for Improving Sugar-Beet Culture," by Truman G. Palmer, in "Progress of the Beet-Sugar Industry" in 1902, U. S. Department of Agriculture; "The Development of Single-germ Beet Seed," by C. O. Townsend and E. C. Rittue, U. S. Department of Agriculture, Bulletin No. 73, 1905; "Progress of the Beet-Sugar Industry" in 1908, U. S. Department of Agriculture.

## SUGAR-BEET SEED SITUATION IN 1914, 1915 AND 1916

The present annual seed requirements of American beet-sugar companies are about 150,000 bags of 110 pounds each, practically all of which is imported from Europe, mostly from Germany. During the last 5 pre-war years these imports amounted to nearly 60,000,000 pounds, for which there was paid about $4,500,000.

The bulk of this seed was supplied by one Austrian

and five German growers, with whom advance contracts were placed for several years for a given quantity of seed per year, to be delivered as required and paid for in the usual course of business. With the outbreak of war in Europe, all was changed and ever since August, 1914, the question of securing an adequate supply of sugar-beet seed has been the uppermost thought in the minds of domestic beet-sugar producers. It was a particularly unfortunate time to be cut off from the usual seed supply, as seed stocks in this country never before had been so low. The average New York wholesale price of granulated sugar for the year 1913 had dropped to 4.278 cents per pound, the lowest in history, and in that year Congress had provided that the import duty on foreign sugar should be abolished May 1, 1916, which would still further lower the price of the product. Discouraged at the gloomy outlook, company managements had allowed their seed supply to decline and when war was declared and the price of sugar immediately began to recover, some beet sugar companies did not have a bag of seed on hand for their 1915 planting, others had only a small supply, only a few were well provided. The quantity of home-grown seed was negligible and without seed the factories would remain idle.

It at once became impossible for American beet-sugar companies to secure shipments of seed without first depositing the money in Rotterdam against bills of lading. To secure the seed, it became necessary for the American beet-sugar producers to send two of their number to Rotterdam, prepared to disburse some $800,000 to the various growers, as the seed arrived, and to arrange for its shipment to the United States. Shipping facilities and other complications were such that several months' effort of the committee was required in order to secure sufficient seed for the 1915 planting.

In 1915 the quantity of German seed desired for 1916 planting in the United States amounted in value to 3,500,000 marks, and the German Government having placed an embargo on the export of sugar-beet seed, notified its growers that the only condition upon which the seed could be exported was that the United States first should land foodstuffs or cotton at a German port, to the value of the seed to be exported.

As Great Britain had blockaded German ports and would not recede from her position, the seed situation with American beet-sugar factories became still more acute and from that time until late in 1917, the executive officer of the industry's national association,

together with his staff of office assistants, devoted their time incessantly to the work of securing a sufficient supply of seed to operate the American factories.

With every nation to be dealt with plunged into war, diplomatic relations strained, commercial operations upset, transportation facilities in a chaotic condition and devoted almost exclusively to conveying troops and munitions of war, the maze of red tape which was encountered both in Washington and in foreign capitals in securing export permits, the proper preparation and filing of indemnity bonds guaranteeing that the seed would not be reexported, the securing of British safe sea permits and latterly the securing of ocean bottoms in which to ship the seed from Russia was all but endless.

A meager 15,000 bags was secured from Germany "as a special consideration to the United States." Germany designated the companies and the quantity of seed which each should receive. Although this seed was furnished under the then existing contracts at 8 cents per pound, in such desperate need of seed were some American companies which did not participate in the distribution, that they paid their more fortunate competitors as high as $65 a bag for their surplus seed. It appearing that no more seed could

be secured from either Germany or Austria, a trusted agent was dispatched to Russia. When the Russian seed growers learned of the situation, the price of Russian seed immediately rose to three times its usual value and most of the growers demanded full payment for the seed before leaving their shipping stations, which are located in the vicinity of Kieff. Although these stations are 6000 miles from the port of Vladivostok, with which they were connected by a single-track railway which already was congested with war munition freight and often was closed for weeks to commercial freights, American sugar factories assumed the risk and forwarded a million and a half dollars to Russia without any positive assurance that the seed could be brought out. After months of negotiations and vexatious delays, the seed began to move and all of it reached this country within a year from the time it was purchased.

The desperate quest for seed brought to mind more vividly than ever before the absolute dependence of the domestic beet-sugar industry on foreign countries. This resulted in the production of an increased amount of home-grown seed in 1915, the planting of a considerable area in 1916 and the formation of plans to

increase the production from year to year, with the view of eventually making the industry independent of foreign countries for its seed supply.

## IMPORTANCE OF DOMESTIC SUGAR-BEET SEED PRODUCTION

The increasing and now vital importance of producing in the United States the sugar-beet seed for its domestic requirements is recognized by the U. S. Department of Agriculture and by Congress, as is evidenced by the fact that the appropriation bill of the Department of Agriculture now carries an annual appropriation of $10,000 for experimental work with sugar-beet seed.

The views of the Department are set forth quite fully in the Department's 1916 Year Book by Dr. C. O. Townsend, Pathologist in Charge of Sugar-Beet Investigations, Bureau of Plant Industry, from which the following extracts are reproduced:

Owing to the disturbed agricultural and trade conditions in Europe since August, 1914, the importance of developing an American beet-seed industry of sufficient magnitude to meet our requirements has become imperative. The united efforts of the Department of Agriculture and the Department of State, co-

operating with the beet-sugar companies, after encountering many difficulties succeeded in securing sufficient beet seed, with the surplus then on hand, to meet the planting requirements in 1915; but the combined efforts of those agencies failed to secure sufficient seed to meet the requirements in 1916, with the result that thousands of farmers were deprived of the benefits of this crop, a number of mills were idle, and consequently the capital invested, amounting to several million dollars, was unproductive.

The present seed requirements of the beet-sugar industry in this country are annually not less than 150,000 sacks of 110 pounds each. In order to insure this quantity of seed it would be necessary to have not less than 16,000 acres devoted to seed production; less than one-fourth of this acreage was harvested in 1916. Seven new mills were erected during 1916 and plans are under way for a still larger number in 1917. Assuming the average capacity of these mills to be 1000 tons of roots a day, which is approximately correct, each new mill will require 10,000 acres of beets for a normal run. To plant 10,000 acres of beets, 200,000 pounds of seed, the product of approximately 200 acres of land, would be required for each mill, not considering the necessary replanting. It is apparent, therefore, that the present acreage in seed will do little more than care for the possible expansion of the beet-sugar industry and that the quantity of seed which must be imported will remain approximately the same as heretofore.

The beet-sugar industry in the United States is composed of three distinct branches, namely, beet-seed production, sugar-beet growing, and beet-sugar extraction and refining. They are so linked that each is dependent upon the others, not only for

its complete success, but for its existence. Without seed the sugar-beet industry, in which more than 70,000 American farmers are directly interested, could not exist, and without beets the 84 beet-sugar mills now standing, with an invested capital of more than $100,000,000, would be idle. The beet-seed industry is, of course, the foundation upon which sugar-beet growing and beet-sugar extraction rests. Because of its fundamental character, it is surprising that sugar-beet seed production in this country has not received more general and more earnest attention in the past. The two primary causes that have operated against the development of the sugar-beet seed industry in this country were (1) the fact that a sufficient quantity of seed to meet our requirements was easily obtainable from European countries at a reasonable price and (2) the prevailing idea that conditions in this country, from the standpoint either of labor cost or of climate, would not permit the successful development of the seed industry in the United States. Recent experiences, however, have shown the folly of depending upon foreign countries for our beet-seed supply, while experiments extending over many years have proved the falsity of the opinion relative to labor and climatic conditions.

### Progress in American Sugar-beet Seed Production

The earliest efforts toward sugar-beet culture in this country, in 1830, were made with seed brought from Europe. When the first permanent beet-sugar mill was established in America, in 1879, European seed was used to produce the raw material, and even at the present time, with nearly 80 mills in operation,

requiring upward of 750,000 acres of beets to insure satisfactory runs, farmers are still depending upon foreign countries for the major portion of their seed. It is true, efforts have been made in certain quarters for many years to produce sugar-beet seed in this country, but prior to 1914 they were largely experimental. The first carefully planned effort to grow sugar-beet seed in the United States was made at Schuyler, Neb., in 1891. These experiments were continued for several years under the direction of Dr. Harvey W. Wiley, at that time chief of the Bureau of Chemistry of the United States Department of Agriculture. The results with this seed, in comparison with imported varieties, showed that the American-grown seed had a higher vitality and that the roots produced from this seed possessed a higher sugar content and gave heavier yield than any of the imported varieties tested.

For a number of years the United States Department of Agriculture conducted experiments in sugar-beet seed growing at Fairfield, Wash., with results similar to those obtained at Schuyler, Neb., with reference to both the vitality of the seed and the quality and weight of roots produced. For many years several sugar companies have grown small quantities of commercial sugar-beet seed, and within the past year two of these beet-sugar companies have greatly increased their beet-seed acreage. In some cases the roots used for this purpose have been produced from the commercial imported seed, while in other instances special seed was used. The results of these tests have been successful from the standpoint of germination of the seed and the yield and quality of the roots produced. While there is abundant proof, therefore, that sugar-beet seed satisfactory in

every particular can be grown in this country, few, if any, distinct American strains of sugar beets have been established and used for commercial beet-seed production. All experience in breeding and selection in this and in other lines would indicate that such strains when properly established and thoroughly acclimated if generally used for beet producton will yield even better results than have been obtained in the experiments already carried out. * * *

### Present Problems

As a result of existing conditions surrounding the sugar-beet seed situation in this country two problems are confronting the beet growers and sugar producers at this time, namely, the production of a sufficient quantity of seed to meet the present planting requirements and the establishment in this country of a permanent beet-seed industry which shall meet our future needs. These requirements relate not only to the quantity of seed necessary to plant the desired acreage, but also to the quality of the seed and the quantity and quality of the roots which this seed is capable of producing.

* * * * * * *

See Farmers' Bulletin No. 52, 1897, by Dr. H. W. Wiley.

### Types of Sugar Beets

It is a startling fact that there are in this country no distinct types of commercial sugar beets. If, for example, a field of a given variety of wheat is examined it will be noted that practically every plant bears a striking resemblance to every

other plant in the field, but this is not true of the sugar beet. In any commercial sugar-beet field from Michigan to California, without regard to the name of the so-called variety, can be found from 6 to 20 or more distinct types of beets. Their distinction may be based upon shape, texture, habit of growth, color, and other characters of the leaf, as well as upon shape, texture, quality, etc., of the root. In fact, scarcely two beets growing side by side in the same field have closely related external characters of leaf or root, and the quality of the roots varies in both sugar and purity.

Equally wide variations may be found in the beet-seed fields, especially with reference to habit of growth and yield of seed. It would appear, therefore, that these so-called strains are badly mixed in the process of growth and production or that many strains or varieties are mixed before the seed is sacked. It would seem, however, from the large number of wide variations in the individual beets produced from commercial seed, that the mixed strains or varieties appearing in commercial fields are due more to the method of growth than to artificial mixing. It may be, and probably is, necessary to have mixed strains, or crosses, in order to combine in one plant all the desirable qualities of weight, sugar, and purity. It would seem, however, that little progress can be made in the development of desirable strains of beets until the present mixed varieties are separated into their component strains and the desirable strains recombined in their proper relation. It is no more reasonable to suppose that such a mixture of the present types of sugar beets will give the best results in yield and quality of roots than it is to assume that the highest results in live-stock production can be

reached with mixed breeds of animals. How quickly the Duroc-Jersey or Poland China hog is recognized! Farmers might have gone on raising "razor backs" and thought they were producing pork if these and other distinct types of hogs had not been developed.

It is true that there are some good cows in a mixed herd and not all pure breeds are of equal value. Likewise, there are good sugar beets in these mixtures that are now called by distinct names and not all individuals of a pure type will be of equal value, but the average in both quality and yield is far below the limit of possibilities, and the highest plane of development of the sugar beet will not be reached until distinct strains or types are produced and fixed, so that they will come true from year to year. It will then be possible to work with the individual beet as the unit upon which the quality and yield of roots may be based, with a reasonable expectation that material and permanent improvement in quality and yield of roots may be produced by eliminating the poorer and less desirable individuals. It is not probable that in these pure strains the highest development of both size and quality will be found in any one strain, but it is necessary first to have the pure strains and to know definitely the characters they possess and are capable of transmitting before the necessary steps can be taken to produce by crossing the permanent types in which the roots shall possess the desired qualities of sugar, purity, and yield. At the same time this line of work should develop seed-producing plants of uniform type, with reference to both habit of growth of seed stalks and date of maturity of seed. The development of uniform types is of vital importance not only with reference to the

yield and quality of roots and seed, but also with reference to the cost of production. The first step, therefore, in the development of a permanent beet-seed industry in this country lies in the direction of the development of true types with reference to both seed beets and seed production.

* * * * * * *

## Conclusions

The highest development of the beet-sugar industry in the United States depends upon the establishment of an American beet-seed industry capable of meeting the requirements of the American sugar-beet grower and the beet-sugar producer.

Our experience thus far indicates that American sugar-beet seed is usually superior in germination and capable of producing larger and better roots than the imported seed.

Our soil and climatic conditions, extending over large areas, favor the production of sugar-beet seed in sufficient quantity to meet all future requirements.

Well-defined strains of sugar beets of high yield and quality are essential to the development of a satisfactory seed industry. Enough has been done to prove that by careful and painstaking work such strains can be produced.

No intelligent study of cultural methods in the production of sugar beets or of problems involving a comparison of varieties can be made until uniform and fixed varieties with which to work are available.

The production of strains having roots of uniform size and habit of growth and capable of yielding seed stalks uniform in habit

and growth and maturity should make possible improved cultural methods, especially in the planting of the roots and in the harvesting of the seed, that will reduce greatly the cost of production.

## WORLD PRODUCTION OF SUGAR-BEET SEED

The twenty million tons of sugar annually produced in the world is derived about equally from sugar-beets and from sugar-cane. The cane itself provides the tops and stalks with which to replant or extend the cane area, but beet seed of the best quality can not be produced in many of the sugar-beet areas of the world, and without such seed, no country can produce beet sugar at a profit.

To produce the 10,000,000 tons of beet-sugar, 20 countries have invested upwards of one billion dollars in the erection of 1350 beet-sugar factories, the first requisite for the successful operation of which is an adequate supply of high grade sugar-beet seed, without which failure would be certain.

That the production and control of most of this seed is vested in less than a dozen wealthy seed growers, some of whom employ $20,000,000 in their seed-growing operations, all of whom are located in the Province of Saxony, the total area of which is less than

that of three counties in the State of Ohio, is a fact of more than ordinary significance.

The production of one-half of the world's sugar is dependent upon the dicta of a small group of men in one country and upon the favorable or unfavorable weather conditions which prevail over a few square miles of territory. If for any reason this handful of growers should decline to furnish seed, or should a succession of unfavorable seasons ensue, the beet-sugar industry of the world would be prostrated and the world would be compelled to reduce its consumption of sugar until seed could be produced elsewhere.

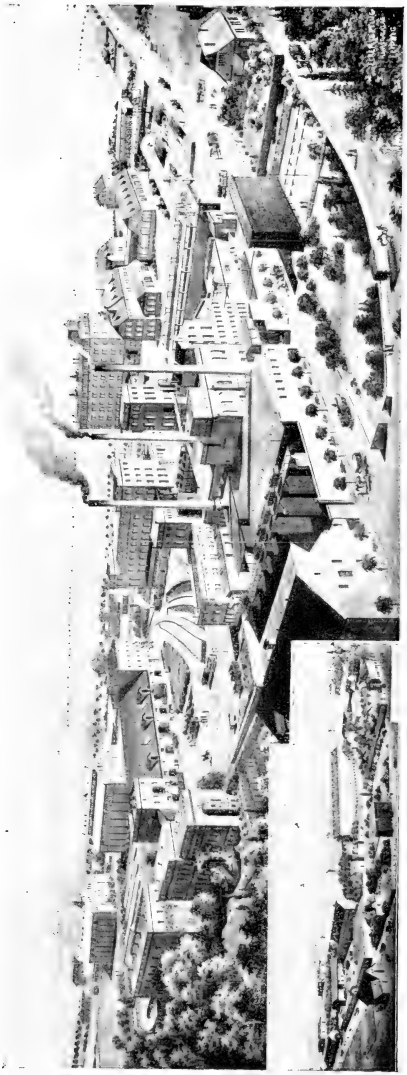
Instances are not lacking where great manufacturing industries are more or less dependent upon foreign countries for some portion of their raw material, but for the production of a great food necessity to be dependent upon so few men and so small an area is without a parallel.

Selection in plant life dates back thousands of years, but Vilmorin originated new and valuable methods of selection, as a result of which the French seed for many years was the best in the world; as late as 1837 Vilmorin's seed sold at 25 to 75 cents per pound when seed grown in Germany sold at $6\frac{1}{2}$ cents per pound.

As the beet-sugar industry began to spread from France to Germany and other countries, they commenced to grow sugar-beet seed, but Germany soon put forth such efforts to produce this primary essen-

P. Louis Leveque de Vilmorin
First to devise methods for increasing the sugar content of the beet.

tial to the industry that growers of other countries soon were driven from the markets of the world and Germany secured a practical monopoly of the business. France, Holland, and Austria still export small



Birds-eye View of Buildings on the Klein Wanzleben Sugar-beet Seed Farm
Capital employed, $23,000,000.

quantities of native seed, but most of their domestic requirements are imported from Germany.

For some years Russian seed growers have produced most of the seed for Russia's domestic sowings, and recently, a small quantity for export. As soon as the Germans realized that seed of as high a quality as that produced in Germany could be produced in certain sections of a few of the governments of southwestern Russia where both land and labor were exceedingly cheap, the leading German seed growers proceeded to acquire large holdings of the choicest lands in those sections where they established extensive seed farms. The scientific work is done in Germany, where all the selections and tests are made with which to produce élite seed, which latter is shipped to Russia and sowed for the commercial crop; this is harvested and shipped to Germany and marketed from there, either as Russian or as German-grown seed.

Cermany and Russia furnish the seed for 90 per cent. of all the beet sugar produced in the world; 69 per cent. of the world crop is from German-grown seed; 78 per cent. of all the beet sugar produced outside of Russia and Germany is from German-grown seed.

LABORATORY BUILDING AT KLEIN WANZLEBEN

Throughout the world about 6,000,000 acres are devoted to sugar beets. Based on an average sowing of 20 pounds of seed per acre in the United States and Canada, 30 pounds in Russia and 25 pounds in all other countries, 1,430,000 bags, or 78,650 tons of sugar-beet seed are required annually, the value of which at the usual pre-war price of $8\frac{1}{2}$ cents per pound, is $14,000,000. Since the beginning of the war in Europe the cost of seed, laid down in the United States has risen from $9.35 to $25.00 per bag of 110 pounds.

The normal sugar-beet seed crop of Germany is 621,000 bags, of Russia 660,000 bags, a total of 1,281,000 bags for the two countries, or 90 per cent. of the total production of all countries. While Russia does not produce as much sugar as does Germany, its sugar-beet area exceeds that of Germany by nearly a half million acres and Russia sows 20 per cent. more seed to the acre. As a result, most of the seed grown in Russia is required for domestic sowing.

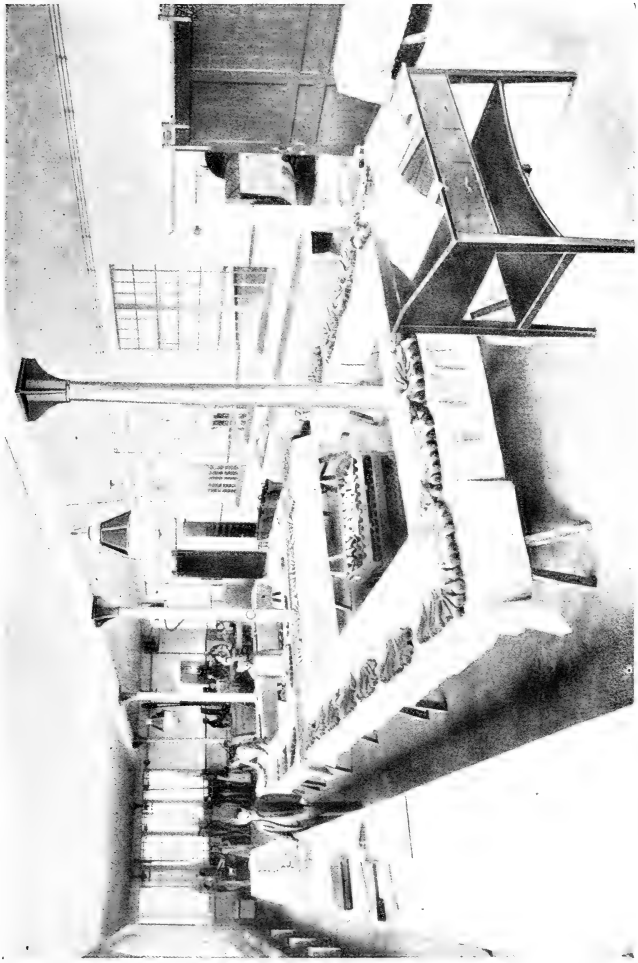
Not including the seed sown in Germany and Russia, the annual seed requirements of the world amount to about 600,000 bags, of which 470,000 bags or 78 per cent. is supplied by Germany from its domestic product and from the 200,000 bags it grows in, or purchases and imports from Russia.

Before the war in Europe most of the American requirements of sugar-beet seed were purchased in Germany. After the outbreak of hostilities American factories failed to secure an adequate supply of seed from Germany and turned to Russia, with the result that in 1916, 175,000 bags were secured, most of which was sowed in the spring of 1917. For the 1918 planting, only domestic and Russian seed is available.

At the present time the beet-sugar world outside of the Central Powers and contiguous neutral countries is relying solely upon Russia for its imports of sugar-beet seed.

Assuming that the German control of Russian seed production does not extend beyond the German imports of Russian seed, the dependence of the world upon German seed in 1913 was as follows:

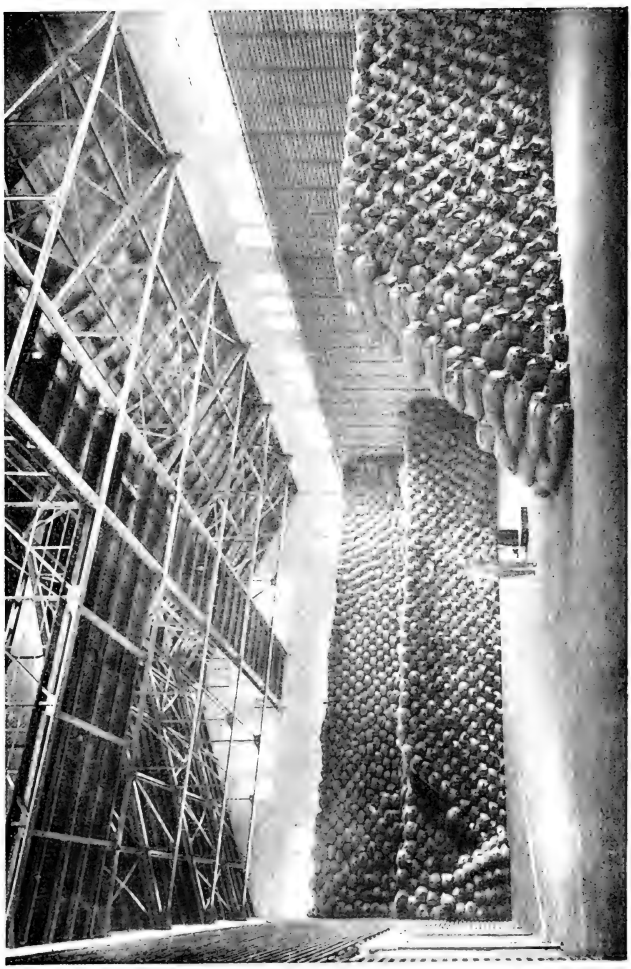
| | Tons. |
|---|---|
| Sugar produced in Germany, from German grown seed | 3,003,768 |
| Sugar produced in other countries from German grown seed | 3,793,365 |
| Total sugar produced from German grown seed | 6,797,133 |
| Sugar produced in Russia, from Russian grown seed | 1,918,443 |
| Sugar produced by seed, other than German and Russian | 1,067,924 |



HEAD LABORATORY FOR SELECTION OF MOTHER BEETS AT KLEIN WANZLEBEN

ROOM FOR EXAMINING THE ANALYZED BEETS WITH RESPECT TO FORM AND OTHER PHYSICAL CHARACTERISTICS. KLEIN WANZLEBEN

BEET-SEED DRYING APPARATUS. KLEIN WANZLEBEN



INTERIOR OF GRANARY FOR CLEANED BEET SEED. KLEIN WANZELEBEN

## UNITED STATES PRODUCTION OF SUGAR-BEET SEED

For several years past, sugar-beet seed has been produced in the United States from imported élite seed and even from the seed of commercial beets, which is equal in every other respect and higher in germinating power than imported seed. The higher germinating power of American seed is accounted for by the fact that it is freshly grown, whereas, in Europe, the seed frequently is a mixture of old and new crops.

Because of the high price of American farm labor the cost of production is greater in the United States than in Russia, where most of the field work is done by women who work in the fields from daylight to dark for an average wage of $17\frac{1}{2}$ cents per day, and in Germany, where they receive $28\frac{1}{2}$ cents per day. But because of the higher germinating power of American seed, an equally good stand of beets can be secured with less seed per acre and the saving in the quantity of seed sown will offset a portion of the increased cost per pound.

Since the difficulty arose in obtaining foreign seed, several American beet-sugar manufacturers have ex-

tended their seed sowings and the members of the United States Sugar Manufacturers' Association, who produce 95 per cent. of all domestic beet-sugar, have formed a coöperative seed-growing company with a cash capital of $300,000; this company has leased a large area of farming land and is now operating extensive seed farms in the State of Idaho. At a cost of $50,000, the company secured in Europe 50 bags of pedigreed "élite" seed which was planted in the spring of 1916. This company also planted several thousand tons of mothers, selected from the best commercial beets growing in the State of Idaho.

The Great Western Sugar Company of Denver, Colorado, has been experimenting in sugar-beet seed growing since 1910. Since the beginning of the war in Europe this company has greatly increased its output of seed, which is grown in Colorado, Montana and Nebraska.

A number of the Michigan sugar companies have begun to raise seed, and are now devoting several hundred acres to this crop. California sugar companies also are devoting some acreage to seed production. As a result of these efforts nearly one-fifth of the seed for the 1918 United States sowings will be raised at home.

A large portion of the seed which the coöperative

seed company is producing in Idaho is grown from the highest pedigreed European "élite" seed, which is imported at a cost of $7.00 to $10.00 per pound. It represents the result of the highest skill of the European sugar-beet seed growers; has passed all the searching physical and chemical examinations and is equal to the élite seed which the European growers themselves plant for producing their commercial seed in Germany and Russia. The Great Western Sugar Company also is importing "élite" seed for some of its plantings. In other cases, selections of mothers are made from beets grown from commercial seed.

However, whether produced from commercial seed or from imported "élite" seed, the effort to grow sugar-beet seed in America is as yet little more than an elemental proposition, for unless the greatest care and attention be given each year to selections, the quality of the beets soon begins to deteriorate, when a new start must be made from freshly imported seed. The character of the seed which we now purchase from Europe indicates that commercialism is sadly interfering with their science in seed production. It has been demonstrated that both élite and commercial foreign seed are mixtures of different varieties of seed or are grown where they cross pollinate with

other types of seed grown in nearby fields. In any commercial field of beets in this country there can be found from six to twenty distinct types of beets, varying in shape, texture, habit of growth, color, sugar content, purity, etc. It is found that when these beets are classified according to type and planted for seed, they reproduce true to the type of the mother. Inasmuch as some types yield better results than do others, it necessarily follows that the highest general results only can be secured by beginning at the very foundation and producing our own élite seed. As well expect to secure satisfactory results by mixing the breed of Jersey, Holstein and Durham cattle instead of breeding them separately and building up each breed, as to expect to secure maximum results in beet culture from a mixture of types of beets. Starting with the best élite seed to be had, the resultant beets must be separated and classified according to type, the best types must be improved by selection and cross breeding from year to year, and from these constantly improving and highly developed types, produce our commercial seed. Instead of deteriorating when planted in this country and allowed to reproduce, the new crop of seed frequently has produced richer beets than were the mothers from which they

sprung. That the effort to improve the beet is worth while, is shown by the fact that if from the $6\frac{1}{4}$ million tons of sugar beets produced by American farmers last year, an increased sugar extraction of 1 per cent had been secured, we would have produced 125,000,000 more pounds of sugar, worth $9,000,000 at present wholesale prices.

Not until America ceases to depend upon Europe for the scientific work which produces the élite seed which we import, and builds up distinctly American strains of seed, will domestic sugar-beet seed production free itself from the domination of Europe and assume the appearance of a real American industry, thereby relieving the domestic beet-sugar industry from dependence upon Germany for its existence.

To secure the highest results, sugar-beet seed culture requires the most fertile lands which are to be had, as well as years of most careful and scientific fertilization and working. Such lands in the vicinity of Magdeburg are held at as high as $1000 per acre.

Unless precedent established by nearly a century's experience in Europe counts for naught, to establish the sugar-beet seed industry in the United States means the investment of hundreds of thousands of dollars in single-unit farms, each covering several

thousand acres, and the carrying on of general farming operations in order properly to rotate and build up the soil. Vast areas of suitable land are to be had in the United States at a fraction of the value of lands which are used for this purpose in Europe. On these farms thousands of dollars must be expended in laboratories and laboratory equipment, in storage warehouses and in the multitude of other necessary buildings and machinery. To operate these farms successfully means the creation of organizations comprising both executive and scientific ability of the highest degree.

Given the proper quantity and quality of land, the equipment and the organization, strains of sugar-beet seed will be developed in the United States which will surpass the best strains in Europe. The cost per pound to produce will be higher than in Europe, but the extra cost will be largely offset by the superior quality of the seed, not to mention the benefits the country will derive from the establishment of a new scientific industry and the freeing of the domestic beet-sugar industry from dependence upon Europe.

## EXPORTS OF SUGAR-BEET SEED FROM GERMANY TO VARIOUS COUNTRIES, AND FROM RUSSIA INTO GERMANY

IN BAGS OF 110.23 POUNDS

From Auswärtiger Handel, Statistik des Deutschen Reichs

| | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | Average per Annum. |
|---|---|---|---|---|---|---|---|---|
| | Bags | Bags | Bags | Bags | Bags | Bags | Bags | Bags |
| Belgium | 29,332 | 26,810 | 35,218 | 39,736 | 49,928 | 26,952 | 35,860 | 34,834 |
| Bulgaria | ..... | ..... | ..... | 592 | 1,184 | 986 | 3,344 | 1,527 |
| Denmark | 10,744 | 6,826 | 6,728 | 10,458 | 12,540 | 10,038 | 16,602 | 10,562 |
| France | 58,538 | 55,432 | 66,672 | 64,986 | 77,954 | 60,148 | 73,794 | 65,361 |
| Italy | 15,398 | 18,264 | 10,776 | 12,878 | 22,158 | 13,202 | 12,158 | 14,976 |
| Netherlands | 16,836 | 16,050 | 19,922 | 29,660 | 19,438 | 16,586 | 22,114 | 20,087 |
| Austria-Hungary | 206,756 | 166,074 | 197,260 | 166,574 | 280,320 | 119,842 | 222,954 | 194,254 |
| Roumania | 5,878 | 6,778 | 7,194 | 7,622 | 8,656 | 3,954 | 6,210 | 6,616 |
| Russia in Europe | 85,942 | 59,542 | 77,206 | 38,490 | 39,396 | 24,206 | 36,754 | 51,648 |
| Sweden | 19,348 | 16,252 | 16,858 | 17,180 | 17,448 | 7,674 | 12,996 | 15,394 |
| Servia | ..... | ..... | 2,558 | 642 | 2,744 | 1,686 | 3,910 | 2,308 |
| Spain | 16,302 | 11,096 | 5,130 | 6,408 | 18,592 | 13,286 | 10,978 | 11,685 |
| Canada | ..... | ..... | 1,482 | ..... | ..... | ..... | ..... | ..... |
| United States | 75,868 | 69,968 | 91,034 | 57,652 | 88,482 | 75,156 | 72,384 | 75,792 |
| Total | 540,942 | 453,092 | 538,038 | 452,878 | 638,840 | 373,716 | 530,058 | 503,938 |
| Russia to Germany | 74,684 | 59,542 | 65,690 | 50,984 | 212,950 | 146,322 | 208,658 | 116,976 |

## VALUE OF EXPORTS OF SUGAR-BEET SEED FROM GERMANY TO VARIOUS COUNTRIES, AND FROM RUSSIA INTO GERMANY

From Auswärtiger Handel, Statistik des Deutschen Reichs

| | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 |
|---|---|---|---|---|---|---|
| | Dollars | Dollars | Dollars | Dollars | Dollars | Dollars |
| Belgium | 192,780 | 140,420 | 339,150 | 391,272 | 456,960 | 359,142 |
| Bulgaria | ..... | ..... | ..... | 4,998 | 9,758 | 11,900 |
| Denmark | 66,640 | 35,700 | 72,590 | 108,052 | 105,910 | 118,048 |
| France | 403,172 | 329,868 | 528,360 | 676,872 | 749,700 | 766,360 |
| Italy | 98,294 | 108,766 | 104,006 | 114,478 | 223,958 | 154,700 |
| Netherlands | 107,338 | 95,438 | 143,514 | 211,106 | 188,020 | 203,728 |
| Austria-Hungary | 1,215,942 | 869,652 | 1,680,756 | 1,560,090 | 2,647,274 | 1,529,864 |
| Roumania | 37,842 | 35,462 | 76,160 | 69,258 | 77,112 | 76,874 |
| Russia in Europe | 526,456 | 340,102 | 785,638 | 425,306 | 418,404 | 307,972 |
| Sweden | 122,332 | 85,204 | 200,634 | 170,646 | 148,036 | 74,732 |
| Servia | ..... | ..... | 27,846 | 6,426 | 19,278 | 11,900 |
| Spain | 112,098 | 65,926 | 44,982 | 69,020 | 193,970 | 192,304 |
| Canada | ..... | ..... | 11,900 | ..... | ..... | ..... |
| United States | 522,886 | 416,262 | 733,278 | 462,672 | 727,566 | 751,128 |
| Total | 3,405,780 | 2,522,800 | 4,748,814 | 4,270,196 | 5,965,946 | 4,558,652 |
| Russia to Germany | 462,196 | 340,102 | 328,440 | 480,522 | 1,140,258 | 2,960,006 |

## VALUE PER POUND OF EXPORTS OF SUGAR-BEET SEED FROM GERMANY TO VARIOUS COUNTRIES, AND FROM RUSSIA INTO GERMANY

From Auswärtiger Handel, Statistik des Deutschen Reichs

| | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 |
|---|---|---|---|---|---|---|
| | Cents per lb. | Cents per lb. | Cents per lb. | Cents per lb. | Cents per lb. | Cents per lb. |
| Belgium | 5.96 | 4.75 | 8.74 | 8.93 | 8.30 | 12.09 |
| Bulgaria | ..... | ..... | ..... | 7.66 | 7.48 | 10.95 |
| Denmark | 5.63 | 4.74 | 9.79 | 9.37 | 7.66 | 10.67 |
| France | 6.25 | 5.40 | 7.19 | 9.45 | 8.72 | 11.56 |
| Italy | 5.79 | 5.40 | 8.76 | 8.06 | 9.17 | 10.63 |
| Netherlands | 5.78 | 5.39 | 6.54 | 6.46 | 8.77 | 11.14 |
| Austria-Hungary | 5.34 | 4.75 | 7.73 | 8.50 | 8.57 | 11.58 |
| Roumania | 5.84 | 4.75 | 9.60 | 8.24 | 8.08 | 17.64 |
| Russia in Europe | 5.56 | 5.18 | 9.23 | 10.02 | 9.63 | 11.54 |
| Sweden | 5.74 | 4.76 | 10.80 | 9.01 | 7.70 | 8.83 |
| Servia | ..... | ..... | 9.88 | 9.08 | 6.37 | 6.40 |
| Spain | 6.24 | 5.39 | 7.95 | 9.77 | 9.46 | 13.13 |
| Canada | ..... | ..... | 7.28 | ..... | ..... | ..... |
| United States | 6.25 | 5.40 | 7.31 | 7.28 | 7.46 | 9.07 |
| Average | 5.71 | 5.05 | 8.01 | 8.55 | 8.47 | 11.07 |
| Russia to Germany | 5.61 | 5.18 | 4.54 | 8.63 | 4.86 | 18.35 |

## ESTIMATED SUGAR-BEET SEED REQUIREMENTS OF THE WORLD

(Based on planting 30 pounds of seed per acre in Russia, 20 pounds in the United States and Canada and 25 pounds in other countries)

| | 1907 | | 1908 | | 1909 | | 1910 | |
|---|---|---|---|---|---|---|---|---|
| | Acres. | Bags of Seed, 110.23 lbs. | Acres. | Bags of Seed. | Acres. | Bags of Seed. | Acres. | Bags of Seed. |
| United States | 370,984 | 67,310 | 364,913 | 66,209 | 420,262 | 76,252 | 398,029 | 72,218 |
| Germany | 1,112,024 | 252,205 | 1,077,813 | 235,374 | 1,131,021 | 256,514 | 1,180,913 | 267,828 |
| Russia | 1,500,717 | 408,432 | 1,288,754 | 350,745 | 1,335,713 | 363,525 | 1,649,145 | 448,827 |
| Austria-Hungary | 830,997 | 188,469 | 816,171 | 185,106 | 798,133 | 181,015 | 914,270 | 207,355 |
| France | 522,866 | 118,585 | 530,751 | 120,374 | 553,256 | 125,478 | 564,969 | 133,259 |
| Belgium | 146,283 | 33,177 | 141,464 | 32,084 | 163,160 | 37,004 | 150,236 | 34,073 |
| Netherlands | 113,517 | 25,745 | 119,472 | 27,096 | 137,857 | 31,266 | 122,687 | 27,825 |
| Sweden | 77,095 | 17,485 | 79,072 | 17,933 | 82,778 | 18,774 | 86,816 | 19,690 |
| Denmark | 37,065 | 8,406 | 37,065 | 8,406 | 41,513 | 9,415 | 54,856 | 12,441 |
| Spain | 98,099 | 22,249 | 61,775 | 14,010 | 49,420 | 11,208 | 49,420 | 11,208 |
| Italy | 102,453 | 23,236 | 111,195 | 25,218 | 88,956 | 20,075 | 101,805 | 23,089 |
| Canada | 10,450 | 1,896 | 8,500 | 1,542 | 13,000 | 2,359 | 12,700 | 2,304 |
| Roumania | 16,405 | 3,721 | 30,888 | 7,005 | 32,123 | 7,285 | 33,754 | 7,655 |
| United Kingdom | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Switzerland | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Other Countries | 14,826 | 3,363 | 13,591 | 3,082 | 16,062 | 3,642 | 13,812 | 3,132 |
| Total | 4,953,781 | 1,174,279 | 4,681,424 | 1,094,184 | 4,863,254 | 1,143,812 | 5,333,412 | 1,270,904 |

## ESTIMATED SUGAR-BEET SEED REQUIREMENTS OF THE WORLD—*Continued*

| | 1911 | | 1912 | | 1913 | |
|---|---|---|---|---|---|---|
| | Acres. | Bags of Seed. | Acres. | Bags of Seed. | Acres. | Bags of Seed. |
| United States | 473,877 | 85,980 | 555,300 | 100,752 | 580,006 | 105,235 |
| Germany | 1,247,213 | 282,866 | 1,353,181 | 306,899 | 1,317,784 | 298,871 |
| Russia | 1,944,677 | 529,259 | 1,886,856 | 513,523 | 1,790,734 | 487,363 |
| Austria-Hungary | 1,000,755 | 226,970 | 1,109,479 | 247,319 | 1,065,742 | 241,709 |
| France | 555,481 | 125,982 | 564,624 | 128,056 | 534,230 | 121,163 |
| Belgium | 150,855 | 34,214 | 163,086 | 36,988 | 136,646 | 30,991 |
| Netherlands | 135,905 | 30,823 | 170,499 | 38,669 | 152,461 | 34,578 |
| Sweden | 71,659 | 16,252 | 67,211 | 15,243 | 70,918 | 16,084 |
| Denmark | 61,775 | 14,010 | 79,986 | 18,141 | 76,354 | 17,317 |
| Spain | 82,121 | 18,625 | 91,427 | 20,735 | 125,937 | 28,562 |
| Italy | 131,260 | 29,769 | 130,963 | 29,702 | 148,260 | 33,605 |
| Canada | 13,200 | 2,395 | 14,750 | 2,676 | 12,900 | 2,340 |
| Roumania | 34,594 | 7,846 | 35,491 | 8,049 | 32,158 | 7,293 |
| United Kingdom | ..... | ..... | 3,300 | 748 | 3,954 | 897 |
| Switzerland | ..... | ..... | ..... | ..... | 2,396 | 543 |
| Other Countries | 19,768 | 4,483 | 22,115 | 5,015 | 19,323 | 4,382 |
| Total | 5,909,940 | 1,409,574 | 6,248,268 | 1,472,515 | 6,069,803 | 1,430,933 |

## FRANCE

### Sugar-beet Seed

Excerpt from Die Deutsche Zuckerindustrie, Ap. 14, 1916, p. 41

| Imports. | | | | Exports. | | | |
|---|---|---|---|---|---|---|---|
| 1916 | 1915 | 1914 | 1913 | 1916 | 1915 | 1914 | 1913 |
| Bags | Bags | Bags | Bags | Bags | Bags | Bags | Bags |
| 20 | 44,400 | 93,800 | 86,020 | 900 | 5,580 | 49,720 | 30,420 |

## EXPORTS OF RUSSIAN SUGAR-BEET SEED INTO GERMANY, 1907 TO 1913 INCLUSIVE

| Years. | Bags. | U. S. Pounds. | Total Value in Dollars. | Value in Cents per lb. |
|---|---|---|---|---|
| 1907 | 74,684 | 8,232,417 | 462,196 | 5.61 |
| 1908 | 59,542 | 6,563,315 | 340,102 | 5.18 |
| 1909 | 65,690 | 7,241,009 | 328,440 | 4.54 |
| 1910 | 50,484 | 5,564,851 | 480,522 | 8.63 |
| 1911 * | 212,950 | 23,473,479 | 1,140,258 | 4.86 |
| 1912 | 146,322 | 16,129,074 | 2,960,006 | 18.35 |
| 1913 | 208,658 | 23,000,371 | ..... | ..... |
| Total..... | 818,330 | 90,204,516 | 5,711,524 | ..... |
| Average Value | ..... | ..... | ..... | 6.33 |

* Severe drouth in Germany.

## EXPORTS OF RUSSIAN SUGAR-BEET SEED INTO AUSTRIA

| Year. | Bags. | Total Value in Dollars. | U. S. Pounds. | Value in Cents per lb. |
|---|---|---|---|---|
| 1909 | 16,316 | 87,346 | 1,798,513 | 4.86 |

*Russia.* Excerpted from *Auswärtige Handel, Statistik des Deutschen Reichs,* Vol. 197, p. 18, for 1907 and 1908. Vol. 231, for 1909, p. 5 (20–*b*).

For 1910, 1911, and 1912, Vol. 260, p. 8.

For 1913, Month issue of *Auswärtige Handel,* December, 1913, p. 12.

*Austria.* Excerpted from *Statistik des Deutschen Reichs,* issued in 1910, p. 5.

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